Amending Import Rules for Clementines from Spain: Final Regulatory Impact Analysis

Policy Analysis and Development
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EXECUTIVE SUMMARY

APHIS is amending 7 CFR 319.56-2jj to include a new set of administrative instructions governing all future imports of clementines from Spain. In addition, during the first shipping season, clementines shall not be distributed in or imported into Arizona, California, Florida, Louisiana, and Texas, as well as Puerto Rico, the U.S. Virgin Islands, the Northern Mariana Islands, Guam, and American Samoa as an additional precaution against the introduction of Medflies, which could severely harm fruit and vegetable industries if introduced into commercial production regions. The delay will provide an opportunity for the efficacy of the regulations to be demonstrated under actual production and distribution conditions for one full shipping season before Spanish clementines are allowed entry into valuable Medfly host production areas in the United States.

In the following analysis, we report estimates of regulatory benefits and costs for importers, wholesalers, retail consumers, federal and state taxpayers, and Medfly host crop producers in the United States. Regulatory benefits associated with U.S. imports of Spanish clementines and regulatory costs associated with potential Medfly introductions are estimated using an economic model, which incorporates salient features of Medfly biology, Medfly field control in Spanish groves, and fruit cutting and inspection procedures in the regulations. We estimate regulatory benefits and costs with and without limited distribution imposed, while focusing on the latter under the assumption that limited distribution will not be imposed after the first shipping season during a typical year. Regulatory benefits and costs for a typical year in the near future are estimated relative to the ban (baseline one), because the ban is currently in effect, and relative to the previous import program (baseline two), because this provides a useful benchmark for measuring relative benefits and costs.

The economic analysis for the proposed rule (APHIS 2002a) used a certainty-equivalence framework (values for biological and economic parameters were based on expected values) to estimate regulatory benefits and costs, which was based on the risk analysis for the proposed rule (APHIS 2002b), the proposed regulations, and economic incentives facing Spanish parties. Because key biological and economic parameters will likely vary from expected values on an intra- and inter-seasonal basis and, more importantly, because the model is nonlinear in these parameters, we use Monte Carlo simulation to examine benefits and costs in the current analysis, following the approach taken in the risk analyses. Other than this change, as well as some changes in additional default biological parameters, the current analysis is very similar to the economic analysis for the proposed rule. As such, the model used in the current analysis draws heavily from the economic analysis for the proposed rule and the risk analysis for the final rule (APHIS 2002c). In addition, public comments received on the economic analysis for the proposed rule indicated that the methods used to estimate annual Medfly introductions were not adequately explained. Therefore, we provide a detailed discussion of the biological model in the analysis accompanying the regulations, where in the interest of transparency we also provide the computer program used to estimate regulatory benefits and costs under the default model.

The results of the analysis indicate that regulatory benefits will outweigh regulatory costs relative to both baselines. Expected regulatory gains per year are roughly $207 million relative to the current ban (baseline one), including $118, $59, and $30 million in expected gains for importers, wholesalers, and consumers, respectively, with practically no increase in expected costs for federal and state taxpayers and agricultural producers in the United States associated with Medfly introductions. In addition, the regulations save an estimated $47,000 in annual Medfly introduction costs potentially incurred under the previous import program. Because import levels under the regulations will more than likely exceed import levels under the previous import program, net welfare associated with international trade in Spanish clementines under the regulations is expected to exceed net welfare under the previous import program by an average $23 million per year. That is, net regulatory welfare relative to the second baseline is $23 million per year.

Regulatory Costs in Spain

Regulatory costs in Spain include purchases of additional Medfly traps for producers, purchases of baits for the traps, monitoring and record keeping costs, additional bait spray costs, additional cold treatment costs, and trust fund expenses. Total annual trap and bait expenses for all Spanish growers under the regulations are only $660, or 8.39E-04% of average export market value during 1999 and 2000 ($78.69 million, FAS 2002). Total annual trust fund expenses for the Spanish government, or its agent, are estimated to be at least $90,000, including 16.15% administrative overhead (West 2002), or 1.14E-01% of average export market value during 1999 and 2000. Total annual cold treatment expenses for all exporters average $1.12 million (± $13 thousand) per year, which is 1.42% of average export value during 1999 and 2000, representing a significantly larger cost on exporters. Because the U.S. market is lucrative relative to markets in the rest of the world and because dramatic price declines in Europe associated with the Spanish clementine ban in the United States indicate that European markets are saturated at recent export levels, we assume that additional cold treatment expenses will not affect supply in the short run.

We were unable to estimate additional costs associated with monitoring and record keeping in Spanish groves, which producers will be required to pay; however, these costs will likely be low. It is not clear if or by how much annual bait sprays and spray costs may increase; however, these costs may be borne entirely by federal and local governments in Spain and therefore not affect production decisions. Because the preceding regulatory costs are low relative to the gross value of the U.S. market and because alternative foreign markets for Spanish clementine growers appear to be saturated at recent export levels, we assume that export supply is perfectly inelastic with respect to U.S. import prices. As a result, marginal production and export costs borne by Spanish parties are not passed on to U.S. importers, wholesalers, and retail consumers. The assumption of perfectly inelastic supply is appropriate for a short-run analysis such as this and does not substantially affect the results of the analysis. Furthermore, assuming inelastic supply allows us to estimate clementine import levels and therefore Medfly introduction costs conservatively, the latter of which increase with import levels.

Fruit Cutting and Rejection Costs

Fruit cutting and rejections of inspectional units in Spain and fruit cutting in the United States reduces U.S. clementine imports by an average 4.91% under the default model (0.99% of average export value for 1999 and 2000), leading to reductions in revenues for importers and wholesalers, consumer benefits, and expected Medfly introduction costs. Fruit will be cut and inspected in Spain at a rate of 200 clementines per inspectional unit, which can include as many as 555 pallets, with exporters choosing the size of the inspectional unit. Losses may also include rejections of inspectional units, where the rejection rate will depend on the proportion of fruit that is infested with Medflies in inspectional units (the infestation rate). A fruit cutting and rejection program occurs at the U.S. port. The economic model incorporates the effects of the fruit cutting and inspection programs in Spain and in the United States, including the rejection of inspectional units, on U.S. import levels and therefore on regulatory costs and benefits.

Medfly Introduction Costs

Because current techniques and technologies used by APHIS have proven safe and effective in eradicating recent Medfly introductions and because most introductions occur in urban areas, we assume that introductions associated with Spanish clementine imports will not lead to long-run Medfly establishments in the United States. Annual Medfly introduction costs are given by the product of the expected number of introductions and an estimate of the cost of one introduction. We use the mean cost of eradicating six recent Medfly introductions in California and Florida during 1997 and 1998 in 2000 dollars, rounded up to $11 million, as our measure of federal and state taxpayer costs per introduction (APHIS 1999). Additional costs borne by producers of Medfly host crops during an introduction (additional field sprays, post-harvest treatments, fruit losses, post-harvest fruit losses, and loss of export markets) are based on producer cost estimates for a large introduction ($2.56 million) rounded up to $3 million (Vo and Miller 1993). Total taxpayer and industry costs associated with a potential Medfly introduction are therefore $14 million in the default model.

Because eradication technologies are safe and effective and because most introductions occur in urban areas, Medfly introductions resulting from the importation of clementines from Spain will more than likely not lead to long-run establishments adversely affecting agricultural production regions in the United States. As a result, we do not incorporate all of the potential costs associated with a potential Medfly introduction for four reasons. First, we do not have data to estimate all of the potential costs. Second, in the aggregate these additional costs will likely not, on average, increase total regulatory costs significantly. At the same time, however, we recognize that some of these costs may be substantial for individual growers. Third, although most Medfly introductions occur in urban areas, we assume, for the purpose of estimating

Medfly introduction costs, that any introduction occurs in a Medfly host production region in the United States. As a result, we may be overestimating Medfly introduction costs in the current analysis. Finally, even if we were to increase Medfly introduction costs by a factor of ten, regulatory costs would not increase significantly and the conclusions of the economic analysis would not be affected. (Please see subsection 2.1.3 Medfly Introduction Costs in the economic analysis accompanying the regulations for more detail on the specification of Medfly introduction costs.)

Medfly Introductions

The number of Medfly introductions per year is given by the product of the number of forty-foot containers imported into areas in the United States suitable for the development of Medfly offspring and the probability that at least one adult male and one adult female (mated pair) survive the export process, in discarded fruit, per forty-foot container. We recognize the fact that, for a Medfly introduction to occur, it will be necessary for mated pairs to survive in their new environments long enough to find suitable hosts, for females to oviposit eggs in fruits that are sufficiently mature, for eggs to survive heat, cold, parasitism and disease, and for the eggs to develop into larvae that survive to adulthood and reproduce successfully. The effect of these other variables on the ability of a mated pair to survive, reproduce, and spread would, in all cases, further reduce the likelihood that Medflies could be introduced into the United States. Because data were not available to estimate the effects of these variables on Medfly introductions, our estimates may overstate the number of Medfly introductions that may actually occur, leading to conservative estimates of Medfly introduction costs under the regulations and under the previous import program.

We estimate the probability that at least one mated pair survives the export process, in discarded fruit, for each forty-foot container that passes fruit cutting and inspection in Spain and in the United States, using the biological model reported in the risk analyses (APHIS 2002b, c). Importantly, the simulations incorporate likely variability in Spanish clementine export levels to the United States, which will contribute to variability in mated pair probabilities per shipment and therefore regulatory costs associated with Medfly introductions. Specifically, designated export quantities are drawn from a probability distribution with a minimum value of 83,631 metric tons, a most likely value of 90,032 metric tons, and a maximum value of 116,406 metric tons. The minimum value is based on the import quantity for marketing season 2000, the most likely value is based on the rate of growth in imports between marketing seasons 1999 and 2000, and the maximum value is based on the average annual rate of import growth during 1989–2000.

The risk analyses (APHIS 2002b, c) examined how the difference in maximum infestation rates under the regulations and under the previous import program reduces the probability of a mated pair entering the United States, specifying a very wide range for the infestation rate under the regulations and a relatively wider range under the previous import program. The risk analyses estimated annual introductions under a worst case scenario, one in which fruit cutting and rejection of inspectional units did not occur and one in which parameters of the infestation rate distributions were specified conservatively. However, the regulations impose powerful economic incentives that will more than likely lead Spanish growers and exporters to manage Medfly populations and select fruit for export to the United States more effectively than was assumed in the risk analyses.

If Medflies are detected in clementine shipments under the new preclearance program, shipments will be diverted to other cheaper markets and growers may lose the right to take advantage of the much more lucrative U.S. market, which typically offers prices 20% higher than prices offered in the rest of the world. In addition, if too many shipments are rejected, the import program will likely be suspended, leading to significant reductions in clementine prices received worldwide. As a result, exporters will more than likely choose shipments designated for the United States from regions in which growers experience below average infestation rates and in which growers manage Medflies very well. Further, although the risk analyses set the maximum infestation rate in Spanish groves at 1.50E-02 under the regulations in order to estimate mated pair probabilities conservatively, the infestation rate that suspends the import program is 1.60E-03 (0.16% fruit infested with Medflies) when the effectiveness of inspectors in identifying infested fruit is fixed at 75%. Because we estimate regulatory costs and benefits in the current analysis during a typical year, as opposed to regulatory costs and benefits under a worst case scenario, we set the maximum infestation rate at 1.60E-03, under the assumption that APHIS inspectors correctly identify an infested fruit 75% of the time. We believe that this specification of the maximum infestation rate is consistent with Spanish grower and exporter profit maximization under the regulations and therefore more appropriate for use in the current analysis. An implicit assumption made in the risk analyses is that APHIS inspectors never correctly identify an infested fruit in order to provide a conservative estimate of the number of potential Medfly introductions under the regulations. We base the 75% inspection efficacy on data reported in the risk analyses. (See subsection 2.1.2 Fruit Cutting and Rejection Costs in the economic analysis accompanying the regulations for information on the specification of inspection efficacy.)

In addition, according to sources cited in the risk analyses, the infestation rate in fruit received by Spanish packinghouses ranged between zero and 1.50E-03, with the latter being associated with poorly managed fields. The most likely infestation rate in the risk analysis was set at 1.00E-03, which is only 33 and 38% lower than the infestation rate associated with poorly managed fields (1.50E-03) and the infestation rate that suspends the import program (1.60E-03), respectively. In addition, the risk analyses state that the most likely infestation rate could have been set at zero, because live Medflies were never observed in Spanish clementine shipments during 1985–2000. Because the regulations provide strong profit incentives for Spanish growers to manage Medfly populations effectively and for exporters to choose clementines from Spanish groves that are not poorly managed, the most likely infestation rate will more than likely be lower than the specification in the risk analyses, which was chosen conservatively. We therefore set the most likely infestation rate equal to the most likely infestation rate specified in the risk analyses, 1.00E-03, multiplied by (1.60E-03 / 1.50E-02), the proportional difference between the infestation rate that leads to suspension of the import program and the maximum infestation rate specified in the risk analyses. (See subsection 2.1.4 Medfly introductions in the economic analysis accompanying the regulations for a more detail.) Again, we believe that this specification of the most likely infestation rate is consistent with Spanish grower and exporter profit maximization under the regulations and therefore an appropriate specification for the current analysis. However, we also estimate regulatory benefits and costs using the infestation rate distribution specified in the risk analyses in order to ensure the reader that the same biological models are used in the current analysis and the risk analyses and in order to examine regulatory welfare under the more conservative distributional specification.

Under the default model, that is, under typical Medfly pressure and effective field control in Spain, annual Medfly introduction costs in the United States average less than $10 per year, because the expected number of introductions is very low. Even when the infestation rate distribution is taken from the risk analyses (which do not consider economic incentives facing Spanish growers and exporters under the regulations and which set fruit cutting and inspection efficacy at 0%), introduction costs average less than $300 per year, with expected introductions per year remaining very low. Under the previous import program, Medfly introduction costs average roughly $47 thousand per year, which is 5.93E-02% of average export value during 1999 and 2000. These results indicate that expected Medfly introduction costs increase with the average infestation rate. However, the percent change in Medfly introduction costs for every percent change in the infestation rate (the infestation rate elasticity of introduction costs) declines as the infestation rate increases, because the rate inspectional units are rejected in Spain increases with the infestation rate. In addition, introduction costs stop increasing with infestation rates at or above the rate that leads to rejection of 100% of the inspectional units in Spain. Because the rate inspectional units are rejected increases rapidly with the infestation rate and because the import program will likely be suspended if too many units are rejected, the regulations will likely be effective in terms of preventing Medfly introductions into the United States, regardless of how high the average annual infestation rate may be.

The Clementine Market

Clementines are not grown domestically in significant quantities; therefore, U.S. consumption during the last 15 years (Snell 2002) has depended on imports from Spain, which contributed 90% of total U.S. imports during 1996–2000 (FAS 2002). Between 1991 and 2000, Spain's annual production of clementines averaged slightly over 1.1 million metric tons. During 1991–2000, Spain exported most of its clementines to Germany, France, the United Kingdom, and the Netherlands; however, exports to the United States grew 45% per year during this period, even though clementine production in Spain grew only 2% per year (FAS 1996–2001, MAPA 1999).

The phenomenal growth in exports to the United States has been due to increased demand, leading to higher import prices in the United States relative to import prices in the rest of the world. During 1989–2000, prices offered by U.S. importers averaged 20% higher than prices offered by all other importing countries, providing incentives sufficient for exporters to ship an average annual 6% of total exports to the United States in 1999 and 2000.

Spain typically exports clementines to the United States during mid-September to mid-March. Morocco, Italy, and Israel also export clementines to the United States during this period; however, during 1996–2000, only 2 and 0.1% of U.S. clementine imports were from Morocco and Italy, respectively, and during 1998-2000, only 0.4% of U.S. clementine imports were from Israel. This suggests that exporters in these countries have not established export market infrastructures sufficient to enable significant increases in shipments to the United States in the short run. In addition, clementines from these countries are typically of lower quality as reflected in lower average prices paid by U.S. importers. As a result, it is assumed that exports from Morocco, Italy, and Israel will not be able to fill the void left by the ban on Spanish clementines in the short run.

It is not clear whether clementine imports and domestically produced tangerines (*Citrus reticulata*) may be substitutes for U.S. consumers. Pollack and Perez (2001) have suggested that the two types of citrus may be substitutes; however, they did not estimate a substitution rate. We estimate the rate of substitution using a linear relationship between tangerine prices received by U.S. producers, a constant, wholesale tangerine consumption, and U.S. clementine imports. Substitutability between clementines and tangerines could not be confirmed statistically; that is, the analysis showed little substitution between domestic tangerines and clementines. In addition, there are differences between Spanish clementines and tangerines, which may be important for

U.S. consumers. In particular, clementines are seedless and packaged in decorative wooden boxes; whereas domestically produced tangerines are generally not seedless and are marketed in bulk quantities. Moreover, U.S. consumption of domestically produced tangerines (233,147 metric tons) was almost three times higher than consumption of clementines (83,631 metric tons) in 2000. Finally, until the ban in the fall of 2001, clementines had been imported into the United States for 15 years. As a result, we do not estimate regulatory impacts on U.S. tangerine producers.

Results of the Economic Analysis

The results of the analysis indicate that regulatory benefits will likely outweigh regulatory costs relative to both baselines. Expected regulatory gains are roughly $207 million relative to the current ban (baseline one), including $118, $59, and $30 million in expected gains for importers, wholesalers, and consumers, respectively, with practically no increase in expected costs for federal and state taxpayers and agricultural producers in the United States. As a result, expected regulatory gains are much higher than expected regulatory costs relative to the current ban, because imports are positive and introduction costs are minimal under the regulations. In addition, due to the trend exhibited in the import data during 1989–2000, import levels under the regulations will more than likely exceed import levels under the previous import program. Furthermore, expected Medfly introduction costs under the previous import program are much higher than expected Medfly introduction costs under the regulations. As a result, net gains under the regulations are expected to exceed net gains under the previous import program by an average $23 million (baseline two), which is due almost entirely to higher imports under the former. (See chapter 3 in the economic analysis accompanying the regulations for a more complete discussion of regulatory welfare impacts.)

Regulatory Effects on Small Entities

The U.S. Small Business Administration defines a small agricultural producer as one with annual sales receipts less than or equal to $750,000. We do not know whether the majority of producers of Medfly host crops (NAICS 111310 Orange Groves, NAICS 111320 Citrus (except Orange) Groves, NAICS 111331 Apple Orchards, NAICS 111332 Grape Vineyards, NAICS 111333 Strawberry Farming, NAICS 111334 Berry (except Strawberry) Farming, NAICS 111335 Tree Nut Farming, NAICS 111336 Fruit and Tree Nut Combination Farming, and NAICS Other Noncitrus Fruit Farming) in the United States are designated as small entities. However, regulatory costs on producers of Medfly host crops will more than likely not be significant, because Medfly introduction costs are low under the regulations, regardless of Medfly pest pressure and field control in Spain. As a result, the regulations will likely not have a significant economic impact on a substantial number of small Medfly host crop producers in the United States.

There are approximately 15 Spanish clementine importers in the United States, three of which import the majority of clementines. In addition, individuals in foreign countries own at least two of the import companies in this list. It is not clear if the majority of U.S. clementine importers are designated as small entities by the SBA. These entities include fresh fruit and vegetable wholesalers (NAICS 422480) with 100 employees or less. In addition, the number of small wholesalers potentially affected by the regulations is not known. Small wholesalers include wholesalers and other grocery stores (NAICS 445110) with annual sales receipts of $23 million or less, warehouse clubs and superstores (NAICS 452910) with annual sales receipts of $23 million or less, and fruit and vegetable markets (NAICS 445230) with annual sales receipts of $6 million or less. Because the percentage of income derived from the sale of clementines by wholesalers is likely to be low, the regulations will likely not have a significant negative impact on any small wholesalers relative to either baseline. In addition, small importers and wholesalers will likely be better off under the regulations relative to the current ban and, during growing seasons characterized by typical Medfly pressure in Spanish groves and effective field control, better off under the regulations relative to the previous import program.

As a result, the regulations will likely not have a significant negative impact on small importers relative to either baseline. Further, because import levels will more than likely increase under the regulations, the effect of the average 2.5 days of additional cold treatment expenditures borne by Spanish exporters, which recall amount to 1.42% of average export value during 1999 and 2000, will likely not lead to a significant price increase, even under the unlikely situation in which all of the additional cost is borne by U.S. importers. Because historical markets for Spanish clementines in Europe appear to be saturated at recent import levels, export supply to the United States may not be extremely elastic, at least in the short run, because U.S. prices will remain higher than prices in European markets under the regulations, and Spanish exporters will not be able to divert supplies to other markets in response to the extra cold treatment costs without experiencing concomitant price declines in those markets. As a result, Spanish exporters will likely export similar and increasing quantities of clementines to the United States, until such time that Spanish clementine production has a chance to respond to changes in the world market associated with the regulations. Finally, during growing seasons in which Medfly pressure is atypically high and field control is ineffective, a higher percentage of shipments designated for export to the United States may be diverted to other markets, reducing import levels, raising import prices, and reducing regulatory gains for small importers relative to the previous import program. In addition, because clementine imports will more than likely be lower during the first shipping season, small importers and wholesalers will likely not realize regulatory gains equal to the previous import program, as imports will more than likely be lower than earlier levels.

Amending Import Rules for Clementines from Spain: Final Regulatory Impact Analysis

1. Introduction

APHIS is amending 7 CFR 319.56-2jj to include a new set of administrative instructions governing all future imports of clementines from Spain.[1] In addition, during the first shipping season, clementines shall not be distributed in or imported into Arizona, California, Florida, Louisiana, and Texas, as well as Puerto Rico, the U.S. Virgin Islands, the Northern Mariana Islands, Guam, and American Samoa as an additional precaution against the introduction of Medflies, which could severely harm fruit and vegetable industries if introduced into commercial production regions. The delay will provide an opportunity for the efficacy of the regulations to be demonstrated under actual production and distribution conditions for one full shipping season before Spanish clementines are allowed entry into valuable Medfly host production areas in the United States.

In the following analysis, we report estimates of regulatory benefits and costs for U.S. importers, wholesalers, retail consumers, federal and state taxpayers, and Medfly host crop producers. We estimate benefits and costs with and without limited distribution imposed, while focusing on the latter under the assumption that limited distribution will not be imposed after the first shipping season during a typical year. We discuss the economic model used to estimate benefits and costs in chapter two. Net regulatory welfare impacts are estimated relative to the current ban and the previous import program. Benefits and costs are estimated relative to the ban, because the ban is currently in effect, and relative to the previous import program, because this provides a useful baseline for examining relative welfare effects. We report the results of the analysis in chapter three, including welfare effects under limited distribution during the first

[1] This is the economic analysis for the final rule. We refer readers interested in background information to the economic analysis for the proposed rule (APHIS 2002a).

shipping season, and close with a discussion of expected impacts on small entities in chapter four.

The economic analysis for the proposed rule (APHIS 2002a) used a certainty-equivalence framework (values for biological and economic parameters were based on expected values) to estimate regulatory benefits and costs, which was based on the risk analysis for the proposed rule (APHIS 2002b), the proposed regulations, and economic incentives facing Spanish parties. Because key biological and economic parameters will likely vary from expected values on an intra- and inter-seasonal basis and, more importantly, because the model is nonlinear in these parameters, we use Monte Carlo simulation to examine benefits and costs in the current analysis, following the approach taken in the risk analysis for the final rule (APHIS 2002c). Other than this change, as well as some changes in default biological parameters, the current analysis is very similar to the economic analysis for the proposed rule. In addition, public comments received on the economic analysis for the proposed rule indicated that the methods used to estimate annual Medfly introductions were not adequately explained. Therefore, we provide an in-depth discussion of the bioeconomic model in chapter 2 and the computer program used to estimate regulatory benefits and costs under the default model in the Appendix.

2. The Bioeconomic Regulatory Model

In this chapter, we discuss the bioeconomic model used to estimate benefits and costs associated with the regulations. We discuss regulatory costs in the first subsection. In the second subsection, we discuss the U.S. clementine market. In the third subsection, we summarize how benefits for importers, wholesalers, and retail consumers in the United States are estimated. We explain how benefit and cost estimates are combined in the calculation of net welfare estimates in the final subsection.

2.1 Regulatory Costs

Because a comprehensive model of Spanish export supply to the United States and the rest of the world is beyond the scope of the current analysis, we estimate regulatory benefits and costs for a range of designated export quantities, assuming export supply is perfectly inelastic with respect to U.S. prices.[2] It is likely that export supply to the United States is not perfectly inelastic with respect to U.S. prices, because the majority of clementines imported from Spain are done so on a consignment basis (Thomas 2002).[3] As we demonstrate below, however, costs borne directly by Spanish parties are expected to be relatively low when compared to the value of clementine exports to the United States. In addition, alternative foreign markets for Spanish clementine growers appear to be saturated at recent export levels. As a result, export supply to the United States will likely be relatively inelastic. Therefore, potential biases resulting from our assumption of inelastic supply are likely to be small. However, we do estimate the effects of the fruit cutting and inspection program on rejected shipments, clementine import levels, and import prices (as well as all other regulatory benefits and costs). In addition, we take into account the effects of the fruit cutting and inspection program on economic incentives facing Spanish growers and exporters under the regulations.

2.1.1 Regulatory Costs in Spain

Increases in Spanish production and export costs include purchases of additional traps for producers, purchases of baits for the traps, monitoring and record keeping costs, additional bait spray costs, additional cold treatment costs, and trust fund expenses. These additional costs will

[2] Initial export quantities are referred to as designated in the analysis, because not all of the clementines initially designated for export to the United States shall be exported to the United States. This is because some fruit will be cut and discarded in Spain and in the United States, and because some of the quantities inspected (inspectional units) might be rejected and not allowed into the United States.

[3] Before, during, and after the growing season exporters enter into contracts with importers, which stipulate minimum export quantities in exchange for a percentage of the price importers receive from U.S. wholesalers.

likely be borne by the Spanish government, ACs (local governments), and exporters. At the mean designated export quantity examined in the analysis (93,361 metric tons), total annual trap and bait expenses for all Spanish growers are only $660, or 7.10E-04% of average export market value under the regulations ($92.904 million, Table 2), the majority of which will be spent on traps that can typically be used for several years.[4] As a result, additional trap and bait expenses will represent small increases in fixed and variable costs, respectively, which will likely not affect production decisions regardless of who pays them. Annual trust fund expenses for the Spanish government or its agent are estimated to be at least $90,000, including 16.15% administrative overhead (West 2002), or 9.62E-02% of average export market value under the regulations. These costs represent a more substantial increase in fixed costs; however, because the increase in fixed costs is small relative to the value of exports, we assume that designated export quantities will not be affected. We were unable to estimate additional costs associated with monitoring and record keeping in Spanish groves, which producers will be required to pay; however, these costs will likely be low, because the Auditing Agencies responsible for monitoring and record keeping are already in place for the FDA pesticide residue program. It is not clear if or by how much annual bait sprays and spray costs may increase; however, these costs may be borne entirely by federal and local governments in Spain and therefore not affect production decisions.

[4] Total clementine acreage (FAS 1996–2001, MAPA 1999) multiplied by the U.S. import proportion of clementine production (Table 1) was used to estimate clementine acreage in the U.S. import program. Expected hectares in the U.S. import program for 2002 was given by expected export quantities in 2002 (Table 1) divided by 21.75, average metric tons per hectare in the U.S. import program during 1989–1999. The expected number of producers in the U.S. import program for 2002 was given by expected hectares divided by 2.18 (hectares per producer). Ninety percent of Spanish clementine producers currently use baited traps (Miller 2002). Expected trap and bait expenses, therefore, were given by the product of 0.10, the expected number of producers in the U.S. import program, and the sum of the cost of one trap ($1.25) and the cost of baiting the trap for six months ($2.10) (Snell 2002).

Historically, the Spanish have exported clementines to the United States under cold treatment at 33 ºF for 11 days or 34 ºF for 12 days under the previously required T107-a cold treatment schedule. Because the detection of live Medflies in cold treated Spanish clementines was linked to potential variation in the application of cold treatment, a panel of scientists and regulatory personnel from APHIS's Plant Protection and Quarantine and USDA's Agricultural Research Service was asked to review the existing literature on the efficacy of cold treatment against the Medfly (APHIS 2002d). After reviewing the panel's recommendations and recent literature on the efficacy of cold treatment, APHIS revised the T107-a cold treatment schedule (APHIS 2002e). Exporters from regions in which Medfly are considered to exist must now cold treat Medfly host crops at 34 ºF for 14 days, 35 ºF for 16 days, or 36 ºF for 18 days, because APHIS believes that the revised schedule will ensure Probit 9 quarantine security. Probit 9 quarantine security could not be confirmed for lower temperatures and shorter time periods and, as a result, these specifications were removed from the revised T107-a cold treatment schedule. As a result, clementines shipped to the United States shall undergo at least two to three days (34 ºF) of extra cold treatment.

We assume the average bulk shipment will undergo an additional 2.5 days of cold treatment. The following daily charges will likely be added to the cost of shipping clementines to the United States in each bulk shipments: $10,000 chartering fee (although this fee is highly variable depending on the availability of bulk ships); $2,160 docking fee ($0.27 per metric tons with an average ship size of 8,000 metric tons); $990 fuel at anchorage fee (five to six tons at $180 per ton); and $0.50 per pallet cold treatment fee (Thomas 2002). The additional 2.5 days of cold treatment adds an average $1.12 million (± $13 thousand) in annual expenses for all exporters under the default model, which is 1.20% of average export value under the regulations.[5] (Throughout the discussion, figures to the right of ± can be used to construct 95% confidence intervals for the population mean.) Because the U.S. market is lucrative relative to markets in the rest of the world and because dramatic price declines in Europe associated with the Spanish clementine ban in the United States indicate that European markets are saturated at recent export levels, we assume that additional cold treatment expenses will not affect supply in the short run.

Recall that export supply is assumed perfectly inelastic. As a result, marginal regulatory costs, which include the extra shipping and cold treatment expenditures and costs for baiting additional traps, additional bait sprays, and monitoring and record keeping (if improved Medfly management on Spanish groves leads to yield effects), cannot be passed on to U.S. importers in the form of reduced supplies and higher prices. Because marginal regulatory costs are low relative to the average value of exports to the United States under the default model, with the possible exception of the additional cold treatment expenses, the results of the analysis are not sensitive to the assumption of supply elasticity. In addition, not incorporating effects of the implicit taxes on Spanish parties allows us to estimate clementine import levels conservatively in terms of the costs associated with Medfly introductions, which increase with the level of exports designated for the United States.

2.1.2 Fruit Cutting and Rejection Costs

Fruit cutting and rejections of inspectional units in Spain and fruit cutting in the United States reduce U.S. clementine imports by approximately 4.91% under the default model (0.99% of average export value for 1999 and 2000), leading to reductions in revenues for importers and

[5] There are an average 30 bulk shipments of Spanish clementines to the United States under the default model.

wholesalers, consumer benefits, and expected Medfly introduction costs.[6] Fruit will be cut and inspected in Spain at a rate of 200 clementines per inspectional unit, which can include as many as 555 pallets, with exporters choosing the size of the inspectional unit.[7] Losses may also include rejections of inspectional units, where the rejection rate will depend on the proportion of fruit that is infested with Medflies (the infestation rate), the sample rate, and the size of the inspectional unit according to the hypergeometric cumulative distribution function.[8] Because the average clementine producer in Spain produces 47.42 metric tons (21.75 metric tons on 2.18 hectares), which is 52.68 pallets or 2.57 forty-foot containers, we assume that the inspectional unit is equal to three forty-foot containers. We do this because the proportion of fruit infested with Medflies in Spain, or the infestation rate, will likely vary on different farms. Therefore, we use an inspectional unit size equal to average farmer output in order to account appropriately for the effect of variability in the infestation rate on the number of inspectional units rejected in Spain and on the number of Medfly introductions in the United States.[9]

The amount of fruit cut and discarded in Spain is given by the number of inspectional units designated for export to the United States multiplied by 200. The rejection rate for each

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[6] The value of cut and rejected fruit is given by the average amount cut and rejected in Spain (4,563 metric tons) plus the average in the United States (5 metric tons) multiplied by the difference in average prices received in the United States and in the rest of the world ($0.92 - $0.75 per kilogram) during 1991–2000 (FAS 2002).

[7] One forty-foot container can contain between 20 and 21 pallets, each of which contains 360 boxes of clementines, each of which can contain between 20 and 25 clementines (APHIS 2002b). We assume that each forty-foot container equivalent contains 20.5 pallets, that each pallet contains 360 boxes (2.5 kilograms per box), and that each box contains 22.5 clementines.

[8] The hypergeometric distribution is appropriate in this case, because it models probabilities associated with random sampling without replacement.

[9] We examined the effect of inspectional unit size on Spanish exporters' gross revenues, which incorporated costs associated with inspectional units diverted to other less lucrative markets and costs associated with import program suspension (the import program was suspended when 20% or more of the units were rejected), and found that gross revenues were maximized when the inspectional unit size was 555 pallets. However, gross revenues were not very sensitive to the size of the inspectional unit under the default model.

inspectional unit is given by the probability that at least one infested fruit is detected in 498,150, where the infestation rate for each unit varies according to a pert distribution and where the inspections are 75% effective in identifying an infested fruit; that is, the infestation rate per inspectional unit is stochastic.[10] A pert distribution is a scaled beta distribution having a minimum, a most likely, and a maximum value, which makes it useful for modeling expert opinion concerning a variable (Vose 2000). We assume that APHIS suspends the import program, instituting an effective ban on the importation of clementines from Spain during the remainder of the shipping season, if the average annual rejection rate for all inspectional units designated for export to the United States is 20% or higher. APHIS has reserved the right to suspend the import program if too many inspectional units are being rejected on a monthly basis. The 20% average annual rejection rate that leads to suspension of the import program in the current analysis is based on expert opinion (Miller 2002) and is a simplification, which allows for conservative estimates of clementine import levels under the regulations. In the event the import program is suspended, we assume that, for every unit rejected, two units pass inspection, so that 40% of the initially designated export quantity is allowed to be exported to the United States, which is half way between the minimum (0%) and maximum (80%) percentages of inspectional units that could pass inspection in the event of a program suspension. However, if the rejection rate exceeds 60%, we assume that the percentage of inspectional units designated

[10] APHIS (2002c) cites a study which reported that sampling for Caribbean fruit flies in grapefruit resulted in an average 35% of the infested fruit being found. Because grapefruit are larger and more difficult to inspect than clementines, which have more translucent fruit sections than grapefruit, we assume that fruit cutting and inspection will detect a larger percentage of infested fruit. Specifically, inspection efficacy for clementines is given by the inspection efficiency for grapefruit (0.35) divided by the ratio of clementine weight (0.111 KG per fruit) to grapefruit weight (0.236 KG per fruit), rounded up to 75%. The estimate of kilograms per clementine was obtained from Oryang (2002), and the estimate of kilograms per grapefruit was obtained from nutritional information Rawolution (2002). Finally, clementine inspection efficacy is incorporated in the calculation of inspectional unit rejections by multiplying the sample size (200 clementines) by the inspection efficacy (0.75), so that, although 200 clementines are sampled from each unit, only 150 are sampled effectively.

for export to the United States diverted to other markets is given by the product of the rejection rate and the number of designated inspectional units.

The expected amount of rejected fruit is given by the product of the mean rejection rate for all of the units inspected, the number of inspectional units designated for export to the United States, and the amount of fruit per inspectional unit less the sample rate (i.e. 498,150 – 200 = 497,950). The expected amount of fruit that is ultimately exported to the United States is given by the amount initially designated for export minus the amount that is cut, rejected, and banned (Table 2). In order to estimate Medfly introduction costs conservatively, we do not reject inspectional units with the highest infestation rates. Rather, rejected inspectional units are chosen randomly. We assume that exporters divert rejected inspectional units to other markets. For simplicity, we assume that exporters do not adjust designated export quantities to the United States in the event inspectional units are rejected.[11]

A fruit cutting and rejection program occurs at the U.S. port. Because approximately 90% of the clementine shipments from Spain are bulk shipments (Thomas 2002), containing on average 2,925 metric tons or 26.325 million fruit, we assume that bulk shipments are the inspectional unit in the United States. The expected amount of fruit that is cut is given by the number of bulk shipments multiplied by 1,500, which is the U.S. fruit sampling rate. The rejection rate per bulk shipment is given by the hypergeometric probability that APHIS inspectors observe at least one infested fruit in 26.325 million, where the infestation rate is given by the average infestation rate in the bulk shipment, the inspections are 75% effective in terms of identifying an infested fruit, and where the infestation rate is reduced according to cold treatment mortality, which varies according to a pert distribution across bulk shipments. The expected

[11] Exporters may substitute shipments initially designated for European markets for shipment to the United States in the event shipments initially designated for the Unites States are rejected. Incorporating substitutions of this nature, however, have only a minor impact on the results of the analysis.

amount of rejected fruit is given by the product of the mean rejection rate across bulk shipments, the number of bulk shipments, and the amount of fruit per bulk shipment less 1,500. The expected amount of fruit ultimately imported into the United States is given by the expected amount initially imported minus the expected amount of fruit cut and rejected (Table 2).

2.1.3 Medfly Introduction Costs

Because current techniques and technologies used by APHIS have proven so effective in eradicating recent Medfly introductions, we assume that introductions associated with Spanish clementine imports will not lead to long-run Medfly establishments in the United States. Most Medfly introductions occur in urban areas and typically do not lead to long-run establishments affecting large agricultural production areas. Six recent introductions in Florida and California during 1997 and 1998 were eradicated in an average 9.33 (± 2.30) months, measured from the initial detection of Medflies to the release of areas from quarantine, affected on average only 2.67 (± 1.49) counties, and cost federal and state taxpayers an average $10.93 (± $10.82) million in 2000 dollars (APHIS 1999). Long-run establishments adversely affecting large Medfly host crop production regions did not result from these recent introductions. In addition, APHIS is continuously improving eradication techniques. In particular, eradication techniques and technologies have improved considerably since the unfortunate Medfly infestation that occurred in Santa Clara County, California during 1980–1982 which, according to public comments received on the proposed rule, cost $100 million to eradicate and $100 million in lost export revenues.

The primary reason why the Santa Clara introduction was so expensive to eradicate, and ended up being so expensive for agricultural producers, was because sterile males and sterile females were released and a required 100:1 sterile-to-fertile Medflies was not met (Miller 2002).

In the current Sterile Insect Eradication Technique (SIT), which has been greatly improved since 1982, extensive population monitoring and cover sprays are used to reduce populations in quarantined areas before the release of sterile males needed to obtain the required 100:1 sterile-to-fertile ratio. Sterile females are no longer released with sterile males in order to increase the likelihood that only sterile males mate with fertile females. Aerial cover sprays with spinosads, an environmentally- and beneficial-insect friendly compound, are used over affected agricultural production regions to reduce Medfly populations; ground applications of spinosads with backpack sprayers are used in urban areas. In emergency situations, APHIS may use malathion bait sprays, both aerially and using backpack sprayers. Then sterile males in amounts appropriate to achieve an expected 100:1 sterile-to-fertile individual ratio are released. As a result, Medfly introductions, should they occur in the future, will more than likely not lead to the devastating economic losses experienced during 1980–1982.

Expected costs associated with Medfly introductions are given by the product of the expected number of introductions and an estimate of the cost of one introduction. We use the mean cost of eradicating the six recent Medfly introductions in California and Florida during 1997 and 1998 in 2000 dollars, rounded up to $11 million, as our measure of federal and state taxpayer costs per introduction (APHIS 1999). Additional costs borne by producers of Medfly host crops during an introduction (additional field sprays, post-harvest treatments, fruit losses, post-harvest fruit losses, and loss of export markets) are based on producer cost estimates for a large introduction ($2.56 million) rounded up to $3 million (Vo and Miller 1993). We do not incorporate potential impacts on other industries that derive income from Medfly host crops, including processors, canners, shippers, and export operations, because estimates for these costs during a typical introduction are not available. Total taxpayer and industry costs associated with a potential Medfly introduction are therefore $14 million in the default model.

We do not account for potential disruptions of integrated pest management (IPM) programs, because these costs will more than likely be small, on average, and because data are not available to estimate these costs. Most Medfly outbreaks in the United States occur in urban areas with little if any commercial crops present. In addition, APHIS's use of spinosad cover sprays and SIT over organic production regions will not harm beneficial insect populations. As a result, current eradication programs, which are extremely successful in eradicating the Medfly, would more than likely not adversely affect the IPM programs of producers of Medfly host crops. It is however important to note that only the parent compound, spinosads, has been registered for use by organic farmers. The compounds needed to dilute the parent compound for use in the field have not been registered for use by organic farmers, although the producer of spinosads is working towards organic registration of the necessary diluents. As a result, organic farmers would not be able to market their crops as organic in the event of a Medfly outbreak that required the use of a spinosad cover spray for three years, even though the IPM program would not be adversely affected. Organic farmers would therefore not be able to obtain premium prices for affected produce. We do not incorporate these profit losses into the costs associated with a Medfly introduction, because data needed to compute the amount of affected produce and price differentials are not available. We recognize that these costs may be significant for some growers; however, because most introductions occur in urban areas and are eradicated safely and effectively, incorporating these costs will likely not increase aggregate introduction costs significantly.

In addition, we do not incorporate potential environmental costs that may be associated with eradication efforts, including costs resulting from APHIS's use of malathion bait sprays in emergencies and increased producer use of conventional insecticides, under the assumption that Medfly infestations associated with Spanish clementine imports are eradicated successfully using environmentally friendly spinosad cover sprays and SIT. We also assume that eradication efforts do not adversely affect the quality of affected produce. As for quality effects, we know of only two studies that estimate levels of pesticide residues on domestically consumed fruits and vegetables, both of which find residues on produce to be extremely low (See NRC 2000 and a reference therein). Unfortunately, we are not aware of any studies that have examined Medfly introduction impacts on Medfly host crop quality and, as a result, can not incorporate potential quality impacts quantitatively. Finally, we do not incorporate reductions in consumer welfare associated with yield losses and post-harvest treatment losses under the assumption that supply reductions associated with Medfly introductions are small relative to the total availability of Medfly host crops in the United States.

We do not incorporate all potential costs associated with a Medfly introduction that happens to occur in an agricultural production region, because most Medfly introductions occur in urban areas far removed from production agriculture. However, we assume that, should an introduction occur, it occurs in an agricultural production region. As a result, we are conservative in our estimation of Medfly introduction costs under the regulations. In addition, although the analysis may not incorporate all of the potential costs associated with a typical Medfly introduction in an agricultural production area, it is anticipated that the additional costs discussed above will likely be low on an aggregate basis. Furthermore, even if we use a Medfly introduction cost ten times higher than the default specification, the conclusions of the analysis are not affected, because the expected number of Medfly introductions under the regulations is very low.

2.1.4 Medfly Introductions

The number of Medfly introductions per year is given by the product of the number of forty-foot containers imported into areas in the United States suitable for the development of Medfly offspring and the probability that at least one adult male and one adult female (mated pair) survive the export process, in discarded fruit, per forty-foot container (APHIS 2002c). Annual introduction costs are given by the product of the number of annual introductions and the cost of eradicating and enduring an introduction ($14 million). We recognize the fact that, for a Medfly introduction to occur, it will be necessary for mated pairs to survive in their new environments long enough to find suitable hosts, for females to oviposit eggs in fruits that are sufficiently mature, for eggs to survive heat, cold, parasitism and disease, and for the eggs to develop into larvae that survive to adulthood and reproduce successfully. The effect of these other variables on the ability of a mated pair to survive, reproduce, and spread would, in all cases, further reduce the likelihood that Medflies could be introduced into the United States. Because data were not available to estimate the effects of these variables on Medfly introductions, our estimates may overstate the number of Medfly introductions that may actually occur, leading to conservative estimates of Medfly introduction costs under the regulations and under the previous import program.

We use Monte Carlo simulation to estimate the probability that at least one mated pair survives the export process, in discarded fruit, for each forty-foot container that passes fruit cutting and inspection in Spain and in the United States, using the biological model specified in the risk analysis (APHIS 2002c). Importantly, the simulations incorporate likely variability in

Spanish clementine export levels to the United States, which will contribute to variability in mated pair probabilities per shipment and therefore regulatory costs associated with Medfly introductions. Let L_i denote the number of viable larvae (larvae that become fertile adults) that survive the export process in discarded fruit from forty-foot container, $i = 1 \ldots N$, delivered to an area suitable for the development of offspring, where N is the number of forty-foot containers that pass fruit cutting and inspection. (Specifically, N is equal to successfully imported metric tons divided by 18.45 metric tons per forty-foot container, rounded to the nearest integer). L_i is given by the product of a fixed number of clementines per forty-foot container (166,050), a fixed proportion of fruit that is discarded per container (0.05), the infestation rate for container i, viable larvae per infested fruit for container i, and the average proportion of viable larvae that survives cold treatment in container i.[12] The fixed number of fruit per container and the fixed proportion of discarded fruit per container are taken from the risk analysis for the final rule (APHIS 2002c). The probability that at least one mated pair survives the export process in discarded fruit in container i is given by $p_i = \left(1 - \exp\left(-L_i/2\right)\right)^2$. Annual introductions are given by the product of the average mated pair probability, in discarded fruit, per forty-foot container, $\sum_{i=i}^{N} p_i \Big/ N$, a fixed annual proportion of forty-foot containers delivered to areas suitable for the development of viable offspring (0.34) in the United States, and the number of forty-foot containers imported, N. The annual proportion of containers delivered to suitable areas is based on an estimated maximum 34% of imported fruit that will likely be delivered to states with citrus production (APHIS 2002c).

[12] The results of the analysis are not affected by drawing fruit per container from the normal distribution specified in the risk management analysis (APHIS 2002c). Therefore, for simplicity, we fixed fruit per container at the mean of the distribution in the risk management analysis.

We assume that the mean number of viable larvae per infested fruit varies across Spanish groves, rather than across infested fruit in individual shipments. Initially, we assumed the latter, because the number of viable larvae will likely vary with each infested fruit. As a result, the relative variability in the mean number of viable larvae per fruit per shipment will decline with the infestation rate, because the number of infested fruit per shipment increases with the infestation rate. That is, the mean number of viable larvae per fruit per shipment will not vary appreciably from the mean, especially in shipments with a high proportion of infested fruit. However, the results of the analysis were not appreciably affected by assuming the former, and the computer program used to run the simulations was much more efficient under the former assumption, because far fewer random variables had to be simulated. As a result, average viable larvae per infested fruit vary for each inspectional unit, or every three forty-foot containers, according to a pert distribution with a minimum value of one, a most likely value of three, and a maximum value of eight (APHIS 2002c).[13] Cold treatment survival varies across bulk shipments, which contain 159 forty-foot containers, according to a pert distribution with a minimum value of zero, a most likely value of 1.00E-06, and a maximum value of 1.00E-05; that is, cold treatment survival was the same for every other 159 forty-foot containers. These parameters simulate likely variation in anticipated Probit 9 quarantine security provided by the improved cold treatment schedule for clementines (APHIS 2002c).

The infestation rate varies for each unit inspected in Spain, or for every other three forty-foot containers, according to a pert distribution with a minimum value of zero, a most likely value of 1.07E-04, and a maximum value of 1.60E-03, and the latter two parameters differ from

[13] Because the infestation rate varies for every other three forty-foot containers and because the results of the analysis were not affected by assuming viable larvae per infested fruit varies for every other three forty-foot containers, we believe that the simplifying assumption is warranted.

those specified in the risk analyses (APHIS 2002b, c, Table 4).[14] The risk analyses examined how the difference in maximum infestation rates under the regulations and under the previous import program reduces the probability of a Medfly introduction, specifying a very wide range for the infestation rate under the regulations and a relatively wider range under the previous import program. The risk analyses estimated annual introductions under a worst case scenario, one in which fruit cutting and rejection of inspectional units did not occur and one in which parameters of the infestation rate distributions were specified conservatively. However, the regulations impose powerful economic incentives that will more than likely lead Spanish growers and exporters to manage Medfly populations and select fruit for export to the United States more effectively than was assumed in the risk analyses.

If live Medflies are detected in inspectional units, those units will be diverted to other cheaper markets and growers may lose the right to take advantage of the much more lucrative U.S. market, which typically offers prices 20% higher than prices offered in the rest of the world, for the remainder of the marketing season. In addition, if too many shipments are rejected, the entire import program will be suspended, leading to significant reductions in clementine prices received worldwide. As a result, exporters will more than likely choose shipments designated for the United States from regions in which growers experience below average infestation rates and in which growers manage Medflies very well. Furthermore, although the risk analyses specify 1.50E-02 as the maximum infestation rate in Spanish groves under the regulations, the infestation rate that suspends the import program is actually much lower, 1.60E-03 (0.16% fruit infested with Medflies), when the effectiveness of inspectors in identifying infested fruit is fixed at 75%. Because we estimate regulatory costs and benefits in the current analysis during a

[14] This is an appropriate assumption because, as previously discussed, each Spanish grower produces approximately the amount of fruit contained in an inspectional unit. As a result, infestation rates will likely vary across inspectional units, because Medfly control will likely vary across Spanish growers.

typical year, as opposed to regulatory costs and benefits under a worst case scenario, we set the maximum infestation rate at 1.60E-03, under the assumption that APHIS inspectors correctly identify an infested fruit 75% of the time. We believe that this specification of the maximum infestation rate is consistent with Spanish grower and exporter profit maximization under the regulations and therefore more appropriate for use in the current analysis. An implicit assumption made in the risk analyses is that APHIS inspectors never correctly identify an infested fruit, allowing for a conservative estimate of the number of potential Medfly introductions under the regulations.

In addition, according to sources cited in the risk analyses, the infestation rate in fruit received by Spanish packinghouses ranged between zero and 1.50E-03, with the latter being associated with poorly managed fields. The most likely infestation rate in the risk analysis was set at 1.00E-03, which is only 33 and 38% lower than the infestation rate associated with poorly managed fields (1.50E-03) and the infestation rate that suspends the import program (1.60E-03), respectively. In addition, the risk analyses state that the most likely infestation rate could have been set at zero, because live Medflies were never observed in Spanish clementine shipments during 1985–2000. Because the regulations provide strong profit incentives for Spanish growers to manage Medfly populations effectively and for exporters to choose clementines from Spanish groves that are not poorly managed, the most likely infestation rate will more than likely be lower than the specification in the risk analyses, which was chosen conservatively. We therefore set the most likely infestation rate equal to the most likely infestation rate specified in the risk analyses, 1.00E-03, multiplied by (1.60E-03 / 1.50E-02), the proportional difference between the infestation rate that leads to suspension of the import program and the maximum infestation rate specified in the risk analyses. Again, we believe that this specification of the most likely infestation rate is consistent with Spanish grower and exporter profit maximization under the regulations and therefore an appropriate specification for the current analysis. However, we also estimate regulatory benefits and costs using the infestation rate distribution specified in the risk analyses in order to ensure the reader that the same biological models are used in the current analysis and in the risk analyses and in order to examine regulatory welfare under the more conservative distributional specification.

Under the default specification of the pert distribution for the infestation rate (zero minimum, 1.07E-04 most likely, 1.60E-03 maximum), 4.90% of the units inspected in Spain are rejected and therefore diverted to other markets. We use this specification to characterize Medfly field control and exporter behavior during a typical year under the regulations. When the infestation rate for each inspectional unit is specified as a pert distribution (zero minimum, 1.00E-03 most likely, 1.60E-03 maximum), which is the same as the default specification except that the most likely value is taken from the risk analyses, 13% of the units inspected in Spain are rejected. We use this specification to characterize Medfly field control and exporter behavior during an atypical year, for example, when Medfly populations are unusually high and field control is ineffective. Under the risk analyses' specification of the pert distribution for the infestation rate (zero minimum, 1.00E-03 most likely, 1.50E-02 maximum), 60% of the inspectional units designated for export to the United States are rejected, because the import program is suspended during each annual simulation of the model. We focus attention on the default specification of the infestation rate distribution in our discussion of regulatory costs and benefits; however, we also discuss costs and benefits during atypical years in order to demonstrate the sensitivity of the results to the infestation rate distribution.

When 100 years are simulated using the default model, that is, under typical Medfly pressure and effective field control in Spain, annual Medfly introduction costs in the United States average only $7.77 (± $0.35) per year under the regulations, because the number of Medfly introductions per year is extremely low, averaging only 5.55E-07 (Table 3). When Medfly pest pressure is atypically high and field control is ineffective in Spain, introduction costs are only slightly higher, averaging only $38.79 (± $1.98) per year, because the number of Medfly introductions remains low, averaging only 2.77E-06 per year. Even when the infestation rate distribution is taken from the risk analyses, introduction costs average only $265.80 (± $18.72) per year, with an average 1.90E-05 introductions per year. As a result, introduction costs under the regulations will more than likely be low, relative to regulatory benefits, even under atypical field conditions in Spain.

The only differences between the models used to simulate Medfly introduction costs under the previous import program and under the regulations are that clementines designated for export to the United States are set equal to U.S. imports in 2000 under the former, the infestation rate distribution is given by the pert distribution specified in the risk analyses (0 minimum, 1.00E-03 most likely, 1.50E-01 maximum), and fruit cutting, inspections, and inspectional unit rejections do not occur under the former. Under the previous import program, Medfly introduction costs average $46.66 thousand (± $2.36 thousand), or 5.93E-02% of average export value for 1999 and 2000, with 3.33E-03 introductions per year (Table 3). Because the same biological model is used to estimate mated pair probabilities in the current analysis and in the risk analyses, the annual mean mated pair probability per forty-foot container under the previous import program reported in Table 3 (2.16E-06) is very similar to the mean mated pair probability reported in the risk analyses (2E-06). In addition, the mean mated pair probability per forty-foot container under the infestation rate distribution specified in the risk analyses, 2.80E-08, is very similar to the mean mated pair probability reported in the risk analysis, 3E-08 (APHIS 2002c).[15] (See Appendix 3 in APHIS 2002c.)

These results indicate that expected Medfly introduction costs increase with the average infestation rate. However, the percent change in Medfly introduction costs for every percent change in the infestation rate (the infestation rate elasticity of introduction costs) declines as the infestation rate increases, because the rate inspectional units are rejected in Spain increases with the infestation rate. In addition, introduction costs stop increasing with infestation rates at or above the rate that leads to rejection of 100% of the inspectional units in Spain. Because the rate inspectional units are rejected increases rapidly with the infestation rate and because the import program will likely be suspended if too many units are rejected, the regulations will likely be effective in terms of preventing Medfly introductions into the United States, regardless of how high the average annual infestation rate may be.

2.2 The Clementine Market

Clementines are not grown domestically in significant quantities; therefore, U.S. consumption during the last 15 years (Snell 2002) has depended on imports from Spain, which contributed 90% of total U.S. imports during 1996–2000 (FAS 2002). During 1991–2000, Spain exported most of its clementines to Germany, France, the United Kingdom, and the Netherlands; however, exports to the United States grew an average 45% per year during this period, even though clementine production in Spain grew only an average 2% per year (FAS 1996–2001, MAPA 1999). The phenomenal growth in exports to the United States has been due to increased

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[15] The biological model used in the current analysis is slightly different from the biological model used in the risk analyses, because variation in key variables was treated differently and because the fruit cutting and rejection program was incorporated in the estimation of clementine import levels in the current analysis. As a result, expected Medfly introductions differ accordingly. See the C++ program included in the Appendix or the risk analyses (APHIS 2002b, c) for more information on the biological model.

demand, leading to high import prices relative to import prices in the rest of the world. During 1989–2000, prices offered by U.S. importers averaged 20% higher than prices offered by all other importing countries, providing incentives sufficient for exporters to ship an average annual 6% of total exports to the United States in 1999 and 2000.

There are several reasons to expect that clementine quantities designated for export to the United States will continue to increase under the regulations. First, the recent establishment of lucrative markets in California suggests that U.S. demand for clementines may continue to grow (Pollack 2002). Second, the recent U.S. ban on Spanish clementine imports led immediately to drastic import price reductions in European markets, because significant quantities initially designated for export to the United States had to be sent to Europe instead. This indicates that European markets are near saturation at current import levels and that U.S. import prices may continue to be high relative to import prices paid in the rest of the world. Third, exporters and importers have invested in a significant amount of infrastructure, which has enabled Spain to take advantage of the relatively high prices offered in the United States.[16] Fourth, if operation of the regulations is successful, Medfly populations in Spanish groves registered in the U.S. import program will be managed more efficiently than before, with only very small increases in costs borne by Spanish producers. This could lead to increased clementine production in Spain.[17]

We simulate benefits and costs for a typical marketing season (one in which limited distribution is not imposed) with initial designated export quantities drawn from a pert

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[16] Exporters have secured extensive shipping contracts, invested in packing sheds and inspection areas in the United States, and typically pay for shipping and cold treatment expenses. Importers, in turn, have invested in cold storage units, labor contracts, and transportation services.

[17] Marginal productivities of productive inputs (as opposed to inputs used in Medfly damage abatement), including irrigation services, fertilizer, and labor may increase as a result, leading to increased use of these inputs and associated increases in production on existing groves. See Lichtenberg and Zilberman (1986) and Saha, Shumway, and Havenner (1997) for classic discussions of insect pest management and agricultural productivity.

distribution with a minimum value of 83,631 metric tons, a most likely value of 90,032 metric tons, and a maximum value of 116,406 metric tons. This distribution was chosen because the minimum, most likely, and maximum values can be based on available data. The data are not sufficient to estimate a conventional supply function precisely, due to low degrees of freedom and the significant increase in exports that occurred between the 1998 and 1999 marketing seasons (Table 1). As a result, it was not possible to obtain a precise estimate of the standard deviation of designated exports about a mean value. In addition, the specified pert distribution is skewed to the right, allowing larger export values greater probabilities of occurring, and therefore allowing for conservative estimates of Medfly introduction costs. The minimum value is based on the import quantity for marketing season 2000, the most likely value is based on the rate of growth in imports between marketing seasons 1999 and 2000, and the maximum value is based on the average annual rate of import growth during 1989–2000 (Table 1).[18] These assumptions are justified in the economic analysis for the proposed rule, to which interested readers are referred (APHIS 2002a).

2.3 Regulatory Benefits

Benefits to importers, wholesalers, and retail consumers associated with the regulations are estimated using areas under aggregate import, wholesale, and retail demand curves bounded by respective prices paid, assuming importers, competitive wholesalers, and retail consumers

[18] U.S. imports of clementines from Spain were used to forecast designated export values, because export and import values reported by the Foreign Agricultural Service differ. One reason they differ is because it takes time to ship clementines from Spain to the United States. As a result, clementines that leave Spain in December of a particular year may not end up in the United States until January of the following year (Habr 2002). Another reason export and import values differ is because some designated U.S. exports may be diverted to other countries during shipment. Because U.S. import quantities are ultimately the variable of interest, we use data on U.S. import values to forecast initial designated export values.

purchase the expected amount of Spanish clementines ultimately exported to the United States.[19] Briefly, data on clementine imports and prices were insufficient to estimate demand curves for any of the sectors precisely. In addition, demand curves have not been estimated in the literature. As a result, an iterative procedure was used to specify Spanish clementine demand curves for the import, wholesale, and retail sectors. A benefit of using the iterative procedure is that demand curves for each of the sectors can be based on very little data on import quantities, import prices, and retail prices. This is important because very little data on retail prices were available. More importantly, the structure of import demand appears to have changed dramatically in 1999 and 2000. As a result, traditional instrumental variable approaches to estimating the demand curve were severely limited by low degrees of freedom. Another benefit of the procedure is that it provides demand specifications for the import and wholesale sectors that are consistent with importer profit maximization under consignment with exporters. A potential drawback of the procedure is that choke prices for each of the demand curves are constrained to be the same.[20]

Pollack and Perez (2001) have indicated that clementine imports and domestically produced tangerines (*Citrus reticulata*) may be substitutes for some U.S. consumers; however, they did not report rates of substitution. Fresh Florida Sunburst tangerine prices were 5.35% higher this year relative to last year during a period in which Spanish clementines were imported (December 9, 2001–January 20, 2002), even though tangerine supplies increased 30% relative to the same period last year (Citrus Administrative Committee 2002). In addition, Fresh Florida

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[19] We refer readers interested in the methods used to estimate and justify our demand specifications to the economic analysis for the proposed rule (APHIS 2002a).

[20] The implicit assumption of equal choke prices may affect the benefit and costs estimates, but not the conclusions of the analysis.

Honey tangerine prices were 1.27% higher this year relative to last year during the period January 6, 2001– February 24, 2002, even though supplies increased 17% over the same period last year. Mean price differences, however, were not statistically different from zero at the 0.05 significance level, and part of the price differences may have been due to increases in tangerine quality.[21]

We examined the substitutability between domestically produced tangerines and clementines imported from Spain by estimating a linear relationship between tangerine prices received by U.S. producers, a constant, wholesale tangerine consumption, and U.S. clementine imports. We used 1989–2000 annual data on fresh tangerine prices, wholesale fresh tangerine consumption, and total tangerine production (NASS 1993, 1998, 2001), and clementine imports (Table 1) in the estimations. The price data were converted to 2000 dollars using the consumer price index for food and beverages at home, oranges and tangerines (ERS 2002). The constant, tangerine production, and clementine imports served as instruments in the instrumental variables estimation procedure. Instrumental variables estimates of the y-intercept ($1.50 / kilogram) and the coefficient estimate on wholesale tangerine consumption (-4.37e-09) were statistically different from zero at the 0.001 significance level. The coefficient estimate on clementine imports was negative (-8.65e-10), indicating clementines and tangerines may be substitutes at the wholesale level; however, the coefficient estimate was not statistically different from zero (p-value = 0.44).[22]

In addition, there are differences between Spanish clementines and domestically produced tangerines, which may be important for some U.S. consumers. In particular,

[21] T-stats were 1.17 and 0.22, respectively, which are lower than the respective critical values of $t_{12,0.025} = 2.18$ and $t_{14,.025} = 2.15$.

[22] The coefficient of determination and standard error of the regression were 0.93 and 0.08, respectively. There were 12 annual observations. Estimates were obtained using the TSP software package.

clementine imports are seedless and are packaged in decorative wooden boxes; whereas, domestically produced tangerines are generally not seedless and are marketed in bulk quantities. Tangerine wholesalers are apparently considering alternative marketing strategies based on the clementine model; however, it is not clear if or when wholesalers will adopt this marketing strategy (Pollack 2002). Moreover, consumption of domestically produced fresh tangerines (233,147 metric tons) was approximately three times higher than consumption of clementines (83,631 metric tons) in the United States in 2000. Finally, the regulations would permit the re-entry of Spanish clementines which, until the ban in the fall of 2001, have been imported into the United States for 15 years. Because it is not clear if tangerines substitute for clementines in the aggregate, more domestically produced tangerines are consumed in the United States relative to clementines, and clementines from Spain have been imported historically the regulations would likely not have a significant impact on U.S. tangerine producers. As a result, we do not estimate impacts associated with the regulations on U.S. tangerine producers in the current analysis. However, if U.S. demand for clementines continues to grow under the regulations and clementines and domestically produced tangerines are substitutes, then the regulations may lead to downward pressure on tangerine prices and profit losses for U.S. tangerine producers.

2.4 Net Welfare

Net welfare associated with the regulations is estimated relative to the current ban and relative to the previous import program for a typical year in the near future in which limited distribution is not imposed. Relative to the current ban, net welfare is given by the sum of gross revenues less clementine payments (profits) for importers and wholesalers and retail consumer benefits, minus costs to taxpayers and fruit and vegetable producers associated with Medfly introductions. Relative to the previous import program, net welfare is given by net welfare under the regulations minus net welfare under marketing season 2000. Benefits under the regulations and under the previous import program are measured using the inverse demand curves specified in Table 2 (APHIS 2002a). We simulated the economic model 100 times and record annual means and 95% confidence intervals for variables used in the calculations of benefits (Table 2), costs (Table 3), and net welfare (Table 4).

For a typical marketing year in which limited distribution is not imposed, mean profits for importers and wholesalers are \$118 million (± \$3 million) and \$59 million (± \$1 million), respectively, mean consumer benefits are \$30 million (± \$697 thousand), thus total regulatory benefits under baseline one are \$207 million (± \$5 million) under the default model (Table 2). Because costs associated with Medfly introductions average only \$7.77 per year (Table 3), net welfare relative to the current ban (baseline one) under the regulations is \$207 million (± \$5 million); that is, not much different from total regulatory benefits (Table 4). Profits for importers and wholesalers are \$105 and \$52 million, respectively, and consumer surplus is \$26 million for a total of \$184 million in total market benefits under the previous import program. Because costs associated with Medfly introductions under the previous import program average \$47 thousand (± \$2 thousand), mean net welfare under the previous import program is \$184 million (± \$2 thousand). As a result, mean net welfare under the regulations relative to the previous import program is \$207 – \$184 = \$23 million (± \$5 million) per year (baseline two).

3. Results of the Economic Analysis

The results of the analysis indicate that regulatory benefits will likely outweigh regulatory costs relative to both baselines (Table 4). Expected regulatory gains are roughly \$207 million (baseline one), including \$118, \$59, and \$30 million in expected gains for importers, wholesalers, and consumers, respectively, with practically no increase in expected costs for federal and state taxpayers and agricultural producers in the United States. As a result, expected regulatory gains are much higher than expected regulatory costs relative to the current ban, because imports are positive and introduction costs are minimal under the regulations. In addition, due to the trend exhibited in the import data during 1989–2000, import levels under the regulations will more than likely exceed import levels under the previous import program. Furthermore, expected Medfly introduction costs under the previous import program are much higher than expected Medfly introduction costs under the regulations. As a result, net gains under the regulations are expected to exceed net gains under the previous import program by an average $23 million (baseline two), which is due almost entirely to higher imports under the former.

Even when Medfly pressure is atypically high and field control is relatively ineffective in Spanish groves, expected regulatory gains are roughly $176 million (baseline one), which include $101, $50, and $25 million in gains for importers, wholesalers, and consumers, respectively. As a result, expected regulatory gains are much higher than regulatory costs relative to the current ban, because imports are positive and Medfly introduction costs are minimal under the regulations, averaging only $39 per year. However, because almost 13% of the inspectional units designated for export to the United States are diverted to other markets when Medfly pest pressure is atypically high, net welfare relative to the previous import program (baseline two) is -$8 million (± $4.53 million), because 2.42% more clementines, or an average 2,021 metric tons, are imported under the previous import program. As a result, importers, wholesalers, and consumers could lose roughly $4.61, $2.30, and $1.15 million, respectively, relative to the previous import program due to reduced supplies and higher prices. The largest losses would be felt in the import sector because of the relatively high (in absolute value) own price flexibility of import demand.

In addition, even when the distribution of the infestation rate is taken from the risk analyses (APHIS 2002b, c), which is characteristic of very high Medfly pest pressure and poor field control in Spain under the economic incentives imposed on Spanish growers and exporters under the regulations, expected regulatory benefits are roughly \$36 million (baseline one), which include \$21, \$10, and \$5 million in gains for importers, wholesalers, and consumers, respectively. Because expected regulatory costs are roughly \$266 under this specification of the infestation rate distribution, expected net welfare relative to the current ban is roughly the same as expected regulatory benefits. However, because an average 35% of the units inspected in Spain are rejected, the import program is always suspended, leading to significant reductions in import levels relative to designated export quantities. Designated export quantities average 92,219 metric tons (± 1,083 metric tons), and U.S. import levels average only 36,879 metric tons (± 433 metric tons); therefore, net welfare relative to the previous import program is -\$148 million under this scenario (baseline two).

Because profit losses to Spanish growers and exporters under this specification of the infestation rate distribution would be extremely high, we assume that infestation rates across Spanish groves will more than likely be characterized by the default specification and, under atypical Medfly pressure and relatively ineffective field control, by the infestation rate distribution examined in the previous paragraph. That is, we believe that, under the regulations, infestation rates will more than likely not be characterized by the infestation rate distribution specified in the risk analyses and, as a result, that regulatory benefits and costs will be more in line with the forecasts reported in the preceding paragraphs. Under the assumption that infestation rate variation across inspectional units in Spain is bounded by our default and upper bound specifications, net regulatory welfare relative to the current ban (baseline one) is positive and varies between \$207 and \$176 million during growing seasons characterized by typical Medfly pressure and effective field control and growing seasons in which Medfly pressure is unusually high and field control is ineffective. Net regulatory welfare relative to the previous import program (baseline two) is also expected to be positive during a typical growing season; however, during atypical growing seasons, significant quantities of fruit may be diverted to other markets, leading to welfare losses for importers, wholesalers, and consumers relative to the previous import program.

The same will be true under the regulations for the first shipping season, because Spanish clementine imports shall be subject to limited distribution. As a result, the structure of aggregate demand will be different during the first shipping season. We assume that import, wholesale, and consumer demand curves shift under limited distribution, so that aggregate quantities demanded are lower at each price. We also assume that Spanish exporters anticipate the demand shift and reduce exports so that import prices received are approximately the same as they would have been under the regulations without limited distribution. We shift the demand curves to the left by multiplying the y-intercepts by (1 – 0.29), where 0.29 is the proportion of the U.S. population (281,421,906) in Arizona (5,130,632), California (33,871,648), Florida (15,982,378), Louisiana (4,468,976), and Texas (20,851,820) as of April 1, 2000 (USCB 2002). We assume that the demand shifts are parallel, leaving the slope coefficients unaffected. Under the default model, the most likely designated export quantity under limited distribution is given by the quantity that, after 5% fruit loss $(1-88{,}480/93{,}048)\times 100\%$ (Table 2), results in an import price of \$1.05 per kilogram (Table 2). Under limited distribution, the most likely designated export quantity is 55,507 metric tons, which is a fraction 0.62 of the most likely designated export quantity under the default model. We use this fraction applied to the minimum and maximum designated export quantities under the default model to specify the pert distribution (51,561 metric tons minimum, 55,507 metric tons most likely, 71,768 metric tons maximum) used to simulate designated export quantities to the United States during the first shipping season.

Net welfare estimates under limited distribution relative to both baselines are reported in Table 4 under the default model. That is, we assume that Medfly pressure and field control in Spain is typical during the first shipping season. As expected, net regulatory welfare under limited distribution is positive relative to the current ban (baseline one), averaging \$79.57 million (± \$1.99 million), because import levels are positive and Medfly introduction costs are only \$4.86 (± \$0.31) per year. As was also expected, net regulatory welfare under limited distribution is negative relative to the previous import program (baseline two), -\$104.40 million (± \$1.99 million), because import levels under limited distribution average 54,885 metric tons (± 680 metric tons), or 34% lower relative to imports during marketing season 2000. As a result, importers, wholesalers, and consumers will likely experience a 57% decline in benefits associated with Spanish clementine trade during the first shipping season relative to the previous import program. Wholesalers and consumers in states in which importation and distribution are not prohibited will likely not be affected; however, importers who supply wholesalers in Arizona, California, Florida, Louisiana, and Texas, as well as wholesalers and consumers in those states, will experience net losses relative to the previous import program.

However, net regulatory benefits will still be positive relative to the current ban, and net regulatory losses relative to marketing season 2000 will more than likely only obtain for the first shipping season. In addition, the careful examination of the new import program under actual importation and distribution conditions will provide valuable information to APHIS and producers of Medfly host crops in the United States regarding the efficacy of the regulations in terms of improving Medfly field control in Spanish groves and preventing the introduction of live Medflies into the United States. In particular, the import program evaluation period will allow APHIS to examine Medfly infestation rates in Spanish groves, the number of inspectional units diverted to other markets, and the efficacy of the revised cold treatment schedule. Examination of these data under actual market conditions will be extremely valuable in order to ensure the effectiveness of the regulations in terms of their primary objective, the prevention of live Medfly introductions into the United States.

4. Regulatory Effects on Small Entities

The U.S. Small Business Administration defines a small agricultural producer as one with annual sales receipts less than or equal to $750,000. We do not know whether the majority of producers of Medfly host crops (NAICS 111310 Orange Groves, NAICS 111320 Citrus (except Orange) Groves, NAICS 111331 Apple Orchards, NAICS 111332 Grape Vineyards, NAICS 111333 Strawberry Farming, NAICS 111334 Berry (except Strawberry) Farming, NAICS 111335 Tree Nut Farming, NAICS 111336 Fruit and Tree Nut Combination Farming, and NAICS Other Noncitrus Fruit Farming) in the United States are designated as small entities. However, regulatory costs on producers of Medfly host crops will more than likely not be significant, because Medfly introduction costs are low under the regulations, regardless of Medfly pest pressure and field control in Spain. (See Table 3 and subsection 2.1.4 Medfly Introductions.) This is because the number of units rejected in Spain under the regulations increases rapidly with the infestation rate and because the import program is suspended if too many inspectional units are rejected, dramatically reducing the number of fruit infested with Medflies exported to the

United States. In addition, quarantine security is further enhanced by the revised cold treatment guidelines, which ensure Probit 9 mortality. As a result, the number of Medfly introductions under the regulations is low. When these estimates are viewed in light of historical Medfly introductions, the majority of which occur in urban areas far removed from agricultural productions regions, and the safe and effective Medfly eradication techniques available to APHIS in the unlikely event that Spanish clementine imports lead to a Medfly introduction, we believe that the regulations will likely not have a significant economic impact on a substantial number of small Medfly host crop producers in the United States.

There are approximately 15 Spanish clementine importers in the United States, three of which import the majority of clementines. In addition, individuals in foreign countries own at least two of the import companies in this list. It is not clear if the majority of U.S. clementine importers are designated as small entities by the SBA. These entities include fresh fruit and vegetable wholesalers (NAICS 422480) with 100 employees or less. In addition, the number of small wholesalers potentially affected by the regulations is not known. These entities include wholesalers and other grocery stores (NAICS 445110) with annual sales receipts of $23 million or less, warehouse clubs and superstores (NAICS 452910) with annual sales receipts of $23 million or less, and fruit and vegetable markets (NAICS 445230) with annual sales receipts of $6 million or less. Because the percentage of income derived from the sale of clementines by wholesalers is likely to be low, the regulations will likely not have a significant negative impact on any small wholesalers relative to either baseline. In addition, small importers and wholesalers will likely be better off under the regulations relative to the current ban and, during growing seasons characterized by typical Medfly pressure in Spanish groves and effective field control, better off under the regulations relative to the previous import program (Table 4).

As a result, the regulations will likely not have a significant negative impact on small importers relative to either baseline. Further, because import levels will more than likely increase under the regulations, the effect of the average 2.5 days of additional cold treatment expenditures borne by Spanish exporters, which recall amount to 1.42% of average export value during 1999 and 2000, will likely not lead to a significant price increase, even under the unlikely situation in which all of the additional cost is borne by U.S. importers. Because historical markets for Spanish clementines in Europe appear to be saturated at recent import levels, export supply to the United States may not be extremely elastic, at least in the short run, because U.S. prices will remain higher than prices in European markets under the regulations, and Spanish exporters will not be able to divert supplies to other markets in response to the implicit cold treatment tax without experiencing concomitant price declines in those markets. As a result, Spanish exporters will likely export similar and increasing quantities of clementines to the United States, until such time that Spanish clementine production has a chance to respond to changes in the world market associated with the regulations.

Finally, during growing seasons in which Medfly pressure is atypically high and field control is ineffective, a higher percentage of shipments designated for export to the United States may be diverted to other markets, reducing import levels, raising import prices, and reducing regulatory gains for small importers relative to the previous import program. In addition, because clementine imports will more than likely be lower during the first shipping season, small importers and wholesalers will likely not realize regulatory gains equal to the previous import program as imports will more than likely be lower than earlier levels. It is not clear if the implicit cold treatment tax will lead to further reductions in import supply during the first shipping season or during growing seasons in which Medfly pressure is atypically high and field control is ineffective, because clementine quantities diverted to European markets will likely lead to price declines in those markets relative to historical levels. If this is the case, the additional cold treatment expenditures borne by Spanish exporters will not lead to further reduction in U.S. import levels. If however prices in European markets are high enough to increase marginal export quantities to those markets profitably in response to the U.S. cold treatment tax, U.S. import levels will decline further during the first shipping season and during atypical growing seasons; therefore, small importers and wholesalers will likely realize even smaller regulatory gains relative to the previous import program.

Appendix. Program Used to Estimate Benefits and Costs

```
#include <iostream.h>
#include <math.h>
#include <fstream.h>
#include <float.h>
#include <stdlib.h>
#include <time.h>

/*********************************************************************************
This C++ program was used to estimate regulatory benefits and costs under the default model reported in Tables 2,
3, and 4.  To execute the program go to www.borland.com, download a free version of the Borland Version 5.5 C++
Compiler, install the compiler, cut and paste the program into a text editor (e.g. Notepad, Wordpad), save the
program as a text file with a *.cpp extension (not a *.txt extension) in a working directory, compile the program, and
then execute it.  Instructions on compiling and executing C++ programs in a working directory are available on the
web site.  The parameters of the probability distributions can be changed to examine the relationship between
regulatory benefits and costs and model parameters.
*********************************************************************************/

/***************************************************************************
VARIABLE DECLARATIONS
***************************************************************************/
time_t timer; // variable used to represent time values, used to set seeds for random number generator
fstream outfile; // initialize output file variable

const int n = 100; // number of annual iterations
const double k = 3; // number of containers per inspectional unit
const double unitsize = k * 18.45; // inspectional unit size in metric tons
// Proportion of fruit per container discarded in an area suitable
// suitable for the development of Medfly larvae.
const double discarded = 0.05; // fruit discarded in forty-foot containers
const double suitable = 0.34; // proportion of forty-foot containers delivered to suitable area
const double bulkunitsize = ((2500 + 4000) / 2) * (22.5 * 360 / 9000); // bulk shipment size in metric tons
const double exportb = 83631; // baseline metric tons exported
const double fruit = 166050; // fruit per 40-foot container
const int fb = (int) bulkunitsize * 1000 * 9; // fruit per bulk shipment
const int fi = (int) k * 166050; // fruit per inspectional unit
const double scosts = 10000 + 0.27 * 8000 + 180 * 5.5; // daily shipping costs
const double mtp = 22.5 * 360 / 9000; // metric tons per pallet

double dexports[n+1]; // initial designated exports
double rejected[n+1]; // proportion of units rejected in Spain
double fruitspain[n+1]; // fruit loss in Spain
double coldcosts[n+1]; // cold treatment expenses assuming 2.5 days
double fruitus[n+1]; // fruit loss in the United States
double imports[n+1]; // amount imported
double iprice[n+1]; // import price
double iwelfare[n+1]; // importers' gross revenues less payments to exporters
double wprice[n+1]; // wholesale price
double wwelfare[n+1]; // wholesalers' gross revenues less payments to importers
double rpice[n+1]; // retail price
double rwelfare[n+1]; // consumer surplus
double mated[n+1][3]; // probabilityability mated pair in discarded fruit per shipment
double intros2[n+1][3]; // introductions
double shipments[n+1]; // shipments
```

```
double intros[n+1][3]; // expected introductions
double benefits[n+1]; // benefits
double costs[n+1][3]; // costs
double welfare[n+1][3]; // net welfare relative to ban
double netwelfare[n+1]; // net welfare relative to previous import program
double ip = 3.71 - exportb * 1000 * 3.01e-8; // baseline import price
double iw = 0.5 * (3.71 - ip) * exportb; // baseline importer profit
double wp = 3.71 - exportb * 1000 * 1.50e-8; // baseline wholesale price
double ww = 0.5 * (3.71 - wp) * exportb; // baseline wholesale profit
double rp = 3.71 - exportb * 1000 * 7.52e-9; // baseline retail price
double rw = 0.5 * (3.71 - rp) * exportb; // baseline consumer surplus
double benefitsb = iw + ww + rw; // baseline international trade benefits

/***************************************************************************
VARIABLE ALLOCATIONS
***************************************************************************/
int units;
const int maxunits = (int) 116406 / (3 * 18.45) + 1;
const int maxships = (int) maxunits * 3 + 1;
const int maxunits2 = (int) 83631 / (3 * 18.45) + 1;
const int maxships2 = (int) maxunits2 * 3 + 1;
double rate[maxunits]; // infestation rates per inspectional unit under rule
double rateb[maxunits2]; // baesline infestation rates
double viable[maxships]; // viable larvae per infested fruit per container under rule
double viableb[maxships2]; // baseline viable larvae per infested fruit per container
double rates[maxships]; // infestation rates per container under rule
double ratesb[maxships2]; // baseline infestation rates per container
double colds[maxships]; // cold treatment mortality per container under rule
double coldsb[maxships2]; // baseline cold treatment mortality per container

/***************************************************************************
FUNCTIONS
***************************************************************************/
inline int round(double x)
{
return((x - (double) floor(x) >= 0.5) ? floor(x) + 1:floor(x));
}

inline double max(double x, double y)
{
return((x < y) ? y:x);
}

inline double min(double x, double y)
{
return((x < y) ? x:y);
}

inline abs(double x)
{
return((x < 0) ? -x:x);
}

inline sign(double x)
{
if (x != 0)
```

```
		return((x < 0) ? -1:1);
	else
		return(0);
	}

double uniform()
{
// Returns a uniform random number between 0 and 1 using the standard
// random number generator from C++.
return((double) rand() / RAND_MAX);
}

double gammln(double xx)
{
// Returns the log of the gamma function.  From Numerical Recipes in C.
double x, y, tmp, ser;
double cof[6] = {76.18009172947146,-86.50532032941677,
		24.01409824083091,-1.231739572450155,
		0.1208650973866179e-2,-0.5395239384953e-5};
int j;

y = x = xx;
tmp = x + 5.5;
tmp -= (x + 0.5) * log(tmp);
ser = 1.000000000190015;

for (j = 0; j <= 5; j++)
	ser += cof[j] / ++y;

return -tmp + log(2.5066282746310005 * ser / x);
} // end gammln

double betacdf(double x, double a, double b)
{
// Returns the probability that X is less than or equal to x when
// X is distributed beta(a, b) using the extended trapezoid rule.
double r, c, i, h, step;
r = 0;
step = 0.001;
c = exp(gammln(a) + gammln(b) - gammln(a + b)); // constant in the beta(a, b) cdf

for (i = 0; i <= x; i += step)
	{
	if ((i == 0)||(i + step > x))
		h = 0.5;
	else
		h = 1;

	r += step * h * pow(i,a - 1) * pow(1 - i,b - 1) / c;
	}
return(min(r,1));
}

double betarand(double a, double b)
{
// Returns a random number distributed beta(a, b).  This is accomplished by
```

```
// finding the x value that sets u = betacdf(x,a,b), where u is a uniform
// random variable on [0, 1].
double u, x, dx;
u = uniform(); // generate uniform random number
dx = 0.5;
x = dx;

// Use bisection to find x.
while (dx > 0.000001)
        {
        dx *= 0.5;
        x = x - sign(betacdf(x,a,b) - u) * dx;
        }

return(x);
}

double hyperpdf(int m, int k, int n)
{
// Computes the probability that X is zero when X is
// distributed hypergeometric(m,k,n).  Note that this
// is also the cumulative probability, because 0 is the
// beginning of the discrete domain.
double x, y, z, r;

x = -gammln(1);
y = gammln(m - k + 1) - gammln(n + 1) - gammln(m - k - n + 1);
z = gammln(m + 1) - gammln(n + 1) - gammln(m - n + 1);

r = max(min(exp(x + y - z), 1), 0); // make sure in [0, 1]

return(r);
}

void shuffle()
{
// Randomly shuffles the elements in rate.
int j, notdone;
int b[maxunits];
double a[maxunits];
double s1, s2;

for (j = 1; j <= units; j++)
        {
        a[j] = uniform();
        b[j] = j;
        }

do
        {
        notdone = 0;

        for (j = 1; j <= units - 1; j++)
                if (a[j] > a[j + 1])
                        {
                        s1 = a[j + 1];
```

```
                        s2 = b[j + 1];

                        a[j + 1] = a[j];
                        b[j + 1] = b[j];

                        a[j] = s1;
                        b[j] = s2;

                        notdone = 1;
                        } // end if a

        } while (notdone == 1);

for (j = 1; j <= units; j++)
        a[j] = rate[b[j]];

for (j = 1; j <= units; j++)
        rate[j] = a[j];

}

/***************************************************************************
PROGRAM OPERATION
***************************************************************************/
void main()
{
const double k2 = round(bulkunitsize / 18.45); // 40-foot containers per bulk shipment
int rep, i, j, unitsb, ships, shipsb, count, start, end, bulkunits, bulkunitsb;
double reject, allowed, spainreject, mrate, mu, s, cn, p, pb;
double import, cold, low, ml, mx, alpha, beta, expo, v;

// Set seed for the random number generator.
// timer = time(NULL); // computer time
// srand(timer); // base the seed for this run on computer time

// Main loop.
for (rep = 1; rep <= n; rep++)
        {
        // Compute designated export quantity.
        low = 83631; // minimum designated export quantity
        ml = 90032; // most designated export quantity
        mx = 116406; // maximum designated export quantity
        alpha = (mx + 4 * ml - 5 * low) / (mx - low); // beta distribution parameters
        beta = (5 * mx - 4 * ml - low) / (mx - low);
        dexports[rep] = betarand(alpha,beta) * (mx - low) + low; // initial designated export quantity
        expo = dexports[rep]; // initialize exports
        cout << "Replication " << rep << "\n";
        cout << "Metric tons designated for export " << expo << "\n";

        units = round(expo / unitsize); // units inspected in Spain
        unitsb = round(exportb / unitsize); // number of units for baseline (these aren't inspected)

        // Compute the average rejection rate for all inspectional units.
        low = 0; // minimum infestation rate
        ml = 0.001 * (0.0016 / 0.015); // most likely infestation rate under rule
        mx = 0.0016; // infestation rate that leads to suspension of the export program
```

```
alpha = (mx + 4 * ml - 5 * low) / (mx - low); // beta distribution parameters
beta = (5 * mx - 4 * ml - low) / (mx - low);

reject = 0;
for (i = 1; i <= units; i++)
        {
        rate[i] = betarand(alpha,beta) * (mx - low) + low; // infestation rates under rule
        reject += 1 - hyperpdf(fi,round(rate[i] * fi),150); // probability finding at least 1 infested
        }
reject /= (double) units; // mean rejection rate in Spain
rejected[rep] = reject;
cout << "Mean rejection rate in Spain " << reject << "\n";

if (reject < 0.20) // export program is not suspended
        {
        spainreject = reject * (double) units; // units rejected in Spain
        fruitspain[rep] = (reject * (unitsize - 200 / 9000) + 200 / 9000) * (double) units;
        expo -= fruitspain[rep]; // update exports

        // Inspectional units rejected are randomly assigned.
        shuffle(); // inspectional units rejected are randomly assigned
        units = units - round(spainreject); // number of units going to the United States
        }

if ((reject >= 0.2) && (reject <= 0.60)) // export program is suspended
        {
        // For every rejected unit, two units pass inspection.
        // As a result, 60% of units are denies entry into the United States.
        allowed = 0.4 * (double) units; // 40% are allowed into the United States
        spainreject = (double) units - allowed; // 60% are not allowed entry
        fruitspain[rep] = spainreject * unitsize + 0.5 * allowed * 200 / 9000;
        expo -= fruitspain[rep]; // update exports

        shuffle(); // inspectional units rejected are randomly assigned
        units = round(allowed); // number of units going to the United States
        }

if (reject > 0.60) // export program is suspended, but more than 60% of the units are rejected
        {
        spainreject = reject * (double) units; // units rejected in Spain
        fruitspain[rep] = (reject * (unitsize - 200 / 9000) + 200 / 9000) * (double) units;
        expo -= fruitspain[rep]; // update exports

        // Inspectional units rejected are randomly assigned.
        shuffle(); // inspectional units rejected are randomly assigned
        units = units - round(spainreject); // number of units going to the United States
        }


// Compute baseline infestation rates.
low = 0; // baseline minimum infestation rate
ml = 0.001; // baseline most likely infestation rate
mx = 0.15; // baseline maximum infestation rate
alpha = (mx + 4 * ml - 5 * low) / (mx - low); // beta distribution parameters
beta = (5 * mx - 4 * ml - low) / (mx - low);
```

```
for (i = 1; i <= unitsb; i++)
        rateb[i] = betarand(alpha,beta) * (mx - low) + low; // baseline infestation rates

// Compute average larval viability per infested fruit per container.
low = 1; // minimum viable larvae per infested fruit
ml = 3; // most likely viable larvae per infested fruit
mx = 8; // maximum viable larvae per infested fruit
alpha = (mx + 4 * ml - 5 * low) / (mx - low); // beta distribution parameters
beta = (5 * mx - 4 * ml - low) / (mx - low);

for (i = 1; i <= units; i++)
        {
        v = betarand(alpha,beta) * (mx - low) + low; // viable larvae per infested fruit
        for (j = i * (int) k - (int) k + 1; j <= i * (int) k; j++)
                {
                rates[j] = rate[i]; // infestation rates per 40-foot container
                viable[j] = v; // viable larvae per infested fruit per 40-foot container
                }
        }

for (i = 1; i <= unitsb; i++)
        {
        v = betarand(alpha,beta) * (mx - low) + low; // baseline viable larvae per infested fruit
        for (j = i * (int) k - (int) k + 1; j <= i * (int) k; j++)
                {
                ratesb[j] = rateb[i]; // infestation rates per 40-foot container
                viableb[j] = v; // viable larvae per infested fruit per 40-foot container
                }
        }

bulkunits = round(expo / bulkunitsize); // number of bulk shipments
bulkunitsb = round(exportb / bulkunitsize); // number of bulk shipments under the baseline
coldcosts[rep] = 2.5 * ((double) bulkunits * scosts + 0.5 * (expo / mtp )) / 1000;
cout << "Cold treatment costs " << coldcosts[rep] << "\n";

// Run cold treatment on units in bulk shipments under the rule and under the baseline.
// Compute cold-treatment survival rate per 40-foot container.
low = 0; // minimum survival
ml = 0.000001; // most likely survival
mx = 0.00001; // maximum survival
alpha = (mx + 4 * ml - 5 * low) / (mx - low); // beta distribution parameters
beta = (5 * mx - 4 * ml - low) / (mx - low);

ships = round(k * (double) units); // number of 40-foot containers under rule
shipsb = round(k * (double) unitsb); // baseline number of 40-foot containers
cout << "Forty-foot containers " << ships << "\n";

reject = 0;
for (i = 1; i <= bulkunits; i++)
        {
        cold = betarand(alpha,beta) * (mx - low) + low; // cold-treatment survival per bulk unit

        start = round((double) i * k2 - k2 + 1);
        end = round((double) i * k2);

        if (end <= ships)
```

```
		{
		count = 0;
		mrate = 0;
		for (j = start; j <= end; j++)
			{
			mrate += rates[j];
			count++;
			colds[j] = cold;
			}
		mrate /= (double) count;
		}
	else
		{
		count = 0;
		mrate = 0;
		j = round((double) i * k2 - k2 + 1);
		while (j <= ships)
			{
			mrate += rates[j];
			count++;
			colds[j] = cold;
			j++;
			}
		mrate /= (double) count;
		}

	reject += 1 - hyperpdf(fb,round(cold * mrate * fb),1125);

	}

reject /= (double) bulkunits; // mean rejection rate per bulkunit
cout << "Rejection rate in U.S. " << reject << "\n";
fruitus[rep] = (reject * (bulkunitsize - 1.5 / 9) + 1.5 / 9) * (double) bulkunits; // fruit cut in U.S.
cout << "Fruit loss in U.S. " << fruitus[rep] << "\n";
import = expo - fruitus[rep]; // amount finally imported
cout << "Amount imported " << import << "\n";

for (i = 1; i <= bulkunitsb; i++)
	{
	cold = betarand(alpha,beta) * (mx - low) + low; // cold-treatment survival per bulk unit

	if (i * (int) k2 <= shipsb)
		for (j = i * (int) k2 - (int) k2 + 1; j <= i * (int) k2; j++)
	  coldsb[j] = cold;
	else
		{
		j = i * (int) k2 - (int) k2 + 1;
		while (j <= shipsb)
			{
			coldsb[j] = cold;
			j++;
			}
		} // end else
	} // end for i

imports[rep] = import;
```

```
shipments[rep] = import / 18.45;
ships = round(shipments[rep]);

// Compute benefits under the rule.
iprice[rep] = 3.71 - import * 1000 * 3.01e-8;
iwelfare[rep] = 0.5 * (3.71 - iprice[rep]) * import;

wprice[rep] = 3.71 - import * 1000 * 1.50e-8;
wwelfare[rep] = 0.5 * (3.71 - wprice[rep]) * import;

rpice[rep] = 3.71 - import * 1000 * 7.52e-9;
rwelfare[rep] = 0.5 * (3.71 - rpice[rep]) * import;

benefits[rep] = iwelfare[rep] + wwelfare[rep] + rwelfare[rep]; // benefits in 1000$ under the rule

// Compute mean probability of a mated pair in discarded fruit under the rule.  Also, compute
// probability of a mated pair in shipments arriving at suitable locations.
mated[rep][1] = 0.0;
for (i = 1; i <= ships; i++)
        {
        v = pow((1 - exp( - (fruit * rates[i] * viable[i] * colds[i] * discarded) / 2)), 2);
        mated[rep][1] += v;

        if (i == 1)
                intros2[rep][1] = 1 - v;
        else
                if (i <= round(suitable * (double) ships))
                        intros2[rep][1] *= (1 - v);
        }
mated[rep][1] /= (double) ships; // mean mated pair probability per container
intros2[rep][1] = 1 - intros2[rep][1]; // intros

// Baseline mean probability of a mated pair in discarded fruit.  Also, compute probability of
// a mated pair in shipments arriving at a suitable area.
mated[rep][2] = 0.0;
for (i = 1; i <= shipsb; i++)
        {
        v = pow((1 - exp( - (fruit * ratesb[i] * viableb[i] * coldsb[i] * discarded) / 2)), 2);
        mated[rep][2] += v;

        if (i == 1)
                intros2[rep][2] = 1 - v;
        else
                if (i <= round(suitable * (double) shipsb))
                        intros2[rep][2] *= (1 - v);
        }
mated[rep][2] /= (double) shipsb; // baseline mean mated pair probability per container
intros2[rep][2] = 1 - intros2[rep][2]; // baseline intros

// Compute expected intros and costs
intros[rep][1] = mated[rep][1] * suitable * ships; // intros under rule
costs[rep][1] = intros[rep][1] * 14 * 1000; // costs in 1000$ under rule

intros[rep][2] = mated[rep][2] * suitable * shipsb; // intros under rule
costs[rep][2] = intros[rep][2] * 14 * 1000; // costs in 1000$ under rule
```

```
	// Compute benefits relative to ban.
	welfare[rep][1] = benefits[rep] - costs[rep][1];
	welfare[rep][2] = benefitsb - costs[rep][2];
	cout << "Welfare under rule " << welfare[rep][1] << "\n";
	cout << "Baseline welfare   " << welfare[rep][2] << "\n\n";

	// Compute benefits relative to previous import program.
	netwelfare[rep] = welfare[rep][1] - welfare[rep][2];

	} // end of main loop

/************************************************************************
RECORD OUTPUT
************************************************************************/
// The following lines of code can be changed easily changed to allow examination of different outputs.

outfile.open("clementine.txt",ios::app); // output data to clementine.txt in the default directory

mu = 0;
for (i = 1; i <= n; i++) mu += dexports[i] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((dexports[i] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Designated Exports      " << mu << "\n";
outfile << "Standard Deviation      " << s << "\n";
outfile << "Confidence              " << cn << "\n";
outfile << "95% Confidence Interval " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += imports[i] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((imports[i] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Amount Imported         " << mu << "\n";
outfile << "Standard Deviation      " << s << "\n";
outfile << "Confidence              " << cn << "\n";
outfile << "95% Confidence Interval " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += mated[i][1] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((mated[i][1] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Mated pair probability per container under rule " << mu << "\n";
outfile << "Standard Deviation                              " << s << "\n";
outfile << "Confidence                                      " << cn << "\n";
outfile << "95% Confidence Interval                         " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += mated[i][2] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((mated[i][2] - mu),2) / (n - 1);
s = sqrt(s);
```

```
cn = 1.96 * s / sqrt(n);
outfile << "Mated pair probability per container baseline   " << mu << "\n";
outfile << "Standard Deviation                              " << s << "\n";
outfile << "Confidence                              " << cn << "\n";
outfile << "95% Confidence Interval                         " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += shipments[i] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((shipments[i] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Total shipments to the U.S. under rule      " << mu << "\n";
outfile << "Standard Deviation      " << s << "\n";
outfile << "Confidence              " << cn << "\n";
outfile << "95% Confidence Interval " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += intros[i][1] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((intros[i][1] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Introductions under rule " << mu << "\n";
outfile << "Standard Deviation        " << s << "\n";
outfile << "Confidence                " << cn << "\n";
outfile << "95% Confidence Interval   " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += intros[i][2] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((intros[i][2] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Baseline introductions " << mu << "\n";
outfile << "Standard Deviation                " << s << "\n";
outfile << "Confidence                        " << cn << "\n";
outfile << "95% Confidence Interval           " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += benefits[i] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((benefits[i] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Total benefits under rule     " << mu << "\n";
outfile << "Standard Deviation      " << s << "\n";
outfile << "Confidence              " << cn << "\n";
outfile << "95% Confidence Interval " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += costs[i][1] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((costs[i][1] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
```

```
outfile << "Total costs under rule          " << mu << "\n";
outfile << "Standard Deviation       " << s << "\n";
outfile << "Confidence               " << cn << "\n";
outfile << "95% Confidence Interval   " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += costs[i][2] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((costs[i][2] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Total baseline costs                  " << mu << "\n";
outfile << "Standard Deviation               " << s << "\n";
outfile << "Confidence                       " << cn << "\n";
outfile << "95% Confidence Interval           " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += welfare[i][1] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((welfare[i][1] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Welfare relative to ban under rule " << mu << "\n";
outfile << "Standard Deviation               " << s << "\n";
outfile << "Confidence                       " << cn << "\n";
outfile << "95% Confidence Interval           " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += welfare[i][2] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((welfare[i][2] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Baseline welfare relative to ban   " << mu << "\n";
outfile << "Standard Deviation               " << s << "\n";
outfile << "Confidence                       " << cn << "\n";
outfile << "95% Confidence Interval           " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

mu = 0;
for (i = 1; i <= n; i++) mu += netwelfare[i] / n;
s = 0;
for (i = 1; i <= n; i++) s += pow((netwelfare[i] - mu),2) / (n - 1);
s = sqrt(s);
cn = 1.96 * s / sqrt(n);
outfile << "Net welfare relative to baseline " << mu << "\n";
outfile << "Standard Deviation              " << s << "\n";
outfile << "Confidence                      " << cn << "\n";
outfile << "95% Confidence Interval          " << "[" << mu - cn << ", " << mu + cn << "]\n\n";

outfile.close(); } // end  main
```

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Table 1. Spanish clementine production, U.S. imports, and import prices

Year	Mandarin production[a]	Fraction clementines[b]	Clementine production[c]	U.S. imports[d]	Import price[e]
	1000KG		1000KG	1000KG	$/KG
1989	1,453,000	0.70	1,017,100	3,822	$1.13
1990	1,575,500	0.70	1,102,850	6,998	$1.20
1991	1,340,300	0.70	938,210	4,525	$1.14
1992	1,521,400	0.70	1,064,980	5,967	$1.52
1993	1,631,000	0.70	1,141,700	7,948	$1.43
1994	1,784,000	0.70	1,248,800	13,859	$1.29
1995	1,686,000	0.70	1,180,200	14,165	$1.28
1996	1,600,000	0.70	1,120,000	23,126	$1.36
1997	1,970,000	0.66	1,221,400	34,528	$1.43
1998	1,760,000	0.62	1,073,600	35,555	$1.35
1999	2,070,000	0.63	1,242,000	77,685	$1.45
2000	1,779,000	0.60	1,067,400	83,631	$1.19
2001	1,650,000	0.75	1,237,500		
		lowest designated export level		83,631	
		most likely designated export level		90,032	= 83,631(1 + 0.0765)
		highest designated export quantity		116,406	= 83,631(1 + 0.3919)

[a] Spanish mandarin production (FAS 1996–2001, MAPA 1999).

[b] Proportion of mandarin production in Spain that was clementines (FAS 1996–2001). Values before 1995 are based on the 1995 value.

[c] Clementine production in Spain is given by Spanish mandarin production multiplied by the fraction of production that was clementines.

[d] Calendar year imports (FAS 2002). The lower bound on initial designated exports for marketing season 2002 is based on imports in marketing season 2000. The most likely value is based on the rate of growth in imports between 1999 and 2000, approximately 7.65%. The maximum value is based on the average annual rate of growth in imports from 1989–2000, approximately 39.19%.

[e] Import value divided by import quantities (FAS 2002).

Table 2. Means and 95% confidence intervals for select variables used in the calculation of regulatory benefits*

Designated exports	Fruit loss in Spain	Fruit loss in U.S.	Imports	Import price	Import profit	Wholesale price	Wholesale profit	Retail price	Consumer benefits
1000 KG	1000 KG	1000 KG	1000 KG	$ / KG	1000$	$ / KG	1000$	$ / KG	1000$
Under the Regulations									
93,048 (± 1,081)	4,563 (± 55)	5 (± 0.06)	88,480 (± 1,028)	$1.05 (± $0.03)	$118,233 (± $2,792)	$2.38 (± $0.02)	$58,920 (± $1,392)	$3.05 (± $0.01)	$29,539 (± $698)
Under the Previous Import program									
			83,631	$1.19	$105,262	$2.46	$52,456	$3.08	$26,298

* Profits are gross revenues less payments on clementines. Profits and consumer benefits are rounded to the nearest 1000$. All monetary values are in 2000 U.S. dollars. Quantities are rounded to the nearest metric ton. Means and standard deviations were computed for 100 replications of the default model. Benefits for importers, wholesalers, and retail consumers in the United States were given by the area below linear inverse demand curves above price. The specifications for these demand curves, as well as the methods used in the specifications, are provided in the economic analysis for the proposed rule (APHIS 2002a). The y-intercept for the import demand curve is $3.71 per kilogram, and the slope is –3.01e-08. The y-intercept for the wholesale demand curve is $3.71 per kilogram, and the slope is –1.50e-08. The y-intercept for the retail demand curve is $3.71 per kilogram, and the slope is –7.52e-09.

Table 3. Means and 95% confidence intervals for select variables used in the calculation of regulatory costs *

Infestation rate per unit[a]	Viable larvae per infested fruit per unit[a]	Cold treatment survival per bulk shipment[a]	Mean mated pair probability in discarded fruit per forty-foot container (A)	Forty-foot containers passing inspection and delivered to suitable area (B)	Introductions (C=AxB)	Medfly introduction costs (D=$14,000xC) 1000$
			Under the Regulations			
3.38E-04	3.50	2.33E-06	3.40E-10 (± 1.47E-11)	1,631 (± 19)	5.55E-07 (± 2.47E-08)	$7.77E-03 (± $3.46E-04)
			Under the Previous Import program			
2.57E-02	3.50	2.33E-06	2.16E-06	1,541	3.33E-03 (± 1.69E-04)	$46.655 (± $2.36)

* All monetary values are in 2000 U.S. dollars. Means and standard deviations were computed for 100 replications of the default model. See chapter 2 for more on how these values were estimated.
[a] Only means of the distributions are reported.

Table 4. Regulatory benefit, cost, and net welfare estimates relative to the current ban and relative to the previous import program*

Import profit	Wholesale profit	Consumer benefits	Total benefits	Total costs	Net welfare under regulations relative to ban	Net welfare under previous import program	Net welfare under regulations relative to previous import program
(A)	(B)	(C)	(D=A+B+C)	(E)	(F=D-E)	(G)	(H=F-G)
1000$	1000$	1000$	1000$	1000$	1000$	1000$	1000$
Under the Regulations							
$118,233 (± $2,792)	$58,920 (± $1,392)	$29,539 (± $698)	$206,692 (± $4,881)	$7.77E-03 (± $3.46E-04)	$206,692 (± $4,881)	183,969 (± $2.36)	$22,723 (± $4,881)
Under the Regulations for the First Shipping Season							
$45,515 (± $1,141)	$22,682 (± $568)	$11,371 (± $285)	$79,568 (± $1,994)	$4.86E-03 (± $3.14E-04)	$79,568 (± $1,994)	183,967 (± $2.35)	–$104,399 (± $1,994)

* Profits are gross revenues less payments on clementines. All monetary values are rounded to the nearest $1000. All monetary values are in 2000 U.S. dollars. Means and standard deviations were computed for 100 replications of the default model. See section 2.4 Net Welfare for more on how these values are estimated.